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Baranowski, J.

A REQUIRED MINIMUM QUANTITY OF DUST FOR PARTICLE-SIZE DETERMINATION IN A BAHCO DUST-PARTICLE ANALYZER

(Określenie ilości pyłu dla oznaczania składu ziarnowego w separatorze "Bahco")

A technique developed for the particle-size analysis of dust using a Bahco dust-particle analyzer is discussed in detail on the basis of the experimental studies made. A minimum dust quantity required was determined which is lower than the recommended sample size by Polish Standard and by the pertinent literature. A discussion of error was carried out using statistical methods. An optimum sample size was found for which results obtained are within the limits of admissible error.

Particle-size distribution constitutes a parameter of prime importance in all problems related to dust analysis or dust collection and disposal engineering. This parameter is essential in such tasks as:

— evaluation of the dust dispersion range in the atmospheric air and estimation of the dustfall figures,

— estimation of the hazard of airborne dusts to human organisms,

— appraisal of the manufacturing processes and operations, in the first place in relation to the size reduction operations,

— suitable choice and evaluation of the performance of the dust collection equipment.

The dust particle-size analysis is one of the most difficult problems of the dust analysis. This is primarily due to the lack of unambiguous definition of the size of a dust particle. A great variety of the process dusts that lack in individuality, as well as diverse methods available for determination of their particle-size distribution, are responsible for the fact that the dust particle size is an arbitrary quantity. Only division of the methods that are suitable for the particle-size analysis below or above 63 μm, respectively, has become of general acceptance.

This paper is devoted to a detailed presentation of the method of dust particle-size analysis in a countercurrent of air using a Bahco dust-particle

analyzer [1]. In conformity with the manufacturers' recommendations [1], literature data, and in compliance with the relevant Polish Standard [2]–[6], a minimum quantity of dust required for the analysis is 10 g. This quantity, however, for a diversity of reasons, is not always available. Under similar circumstances the analysis should be given up which would, however, substantially impair the completeness of the results. Some investigators use a standard loose material of a known particle-size distribution below or above 63 μm, respectively, in a suitable quantity to make up to the required 10 g. This makeup is considered in the tare weight of the weighing bottle in which the weight loss upon centrifugation is determined. A suitable standard material is not always available. Based on the experience with commonly accessible loose material standards a remarkable scatter of the results from random samples is observed. Thus the above method of making up with a standard loose material cannot universally be used, so as to obtain satisfactory results as to the particle-size distribution of a dust sample under analysis. In view of the foregoing the following objectives were assumed in this study:

— to carry out several determinations of particle-size distribution using the starting dust quantities ranging 10 to 5 g without addition of any standard material,

— to make a discussion of error of the results obtained for the starting quantity of dust used in the range from 10 to 5 g, at an assumed confidence level by statistical methods,

— to determine an optimum dust quantity required for the analysis, for which the results obtained would remain within the limits of admissible errors.

The following materials were used in the study: feldspar powder, a PVC manufacturing plant dust, Portland cement grade 250, and a blast-furnace dust.

It will be noted that the data obtained in the study is meant to make the dust analysis technique using a Bahco analyzer a more flexible method, and to enable the application range of this method to be substantially extended. These are not devised, however, to raplace or to undermine the recommendations of the Polish Standard [6] or of the literature findings [1]–[5].

General Procedure in the Use of the Bahco Dust Analyzer

The principle of the method of centrifugation in an air countercurrent in the dust particle-size analysis is explained in Fig. 1. Dust particles under analysis are fed through an annular delivery port *2* into the separa-

tion duct *1* in which air is forced to flow at a known speed V. The separation duct is caused to rotate. Two opposite forces act upon a dust particle, namely, a centrifugal force P and the force due to the resistance to flow of the particle in the medium. The centrifugal force is evaluated from relation

$$P = \frac{\pi d^3}{6}\left(\gamma_d - \gamma_m \omega^2 r\right) \tag{1}$$

where

ω — the angular velocity of rotation.

r — the radius of rotation (here the radius at which separation of the dust particles occurs,

γ_d — dust density,

γ_m — density of the medium,

d — geometric diameter of a dust sphere (of a dust particle).

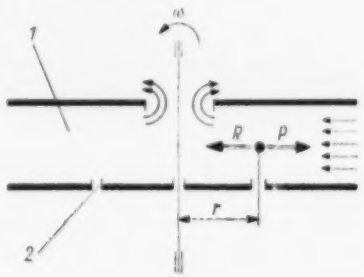

Fig. 1. Diagram of the method of centrifugation in countercurrent of air: *1* — separation duct, *2* — annular delivery port.

The dust particles for which

$$P = R \tag{2}$$

will have a zero velocity relative to the duct, whereas those for which

$$P > R \tag{3}$$

will move off the center, and those for which

$$P < R \tag{4}$$

will move toward the center. Separation of dust particles into particular size ranges in a Bahco analyzer (Fig. 2) is accomplished by centrifugation of a dust sample at various air flow rates. The determination procedure resolves itself into the following general operations:

— a dust sample under analysis is weighed into the dust container,

— successive centrifugations of the sample are performed,

— the loss in weight of the dust is determined subsequent to each

successive centrifugation with respect to the starting weight from the preceding centrifugation.

All the manufacturers of the particle-size analyzers of that kind provide the values for equivalent diameter, d_e, and the settling rate of the individual dust particles V_d. Known the values of the equivalent diameter d_e, the apparent diameter of the dust particles can be found from the relation

$$d_a = d_e/\gamma_d^{1/2} \tag{5}$$

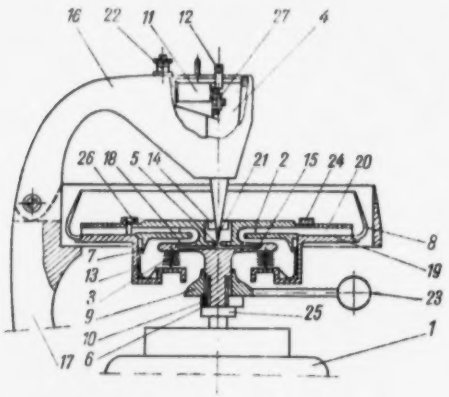

Fig. 2. Schematic drawing of a Bahco particle-size analyzer: *1* — electric motor, *2* — fan, *3* — Lamella type filter cartridges, *4* — feed hopper, *5* — inlet to the separation zone, *6* — throttle body, *7* — collection ring for oversize particles, *8* — collection ring for undersize particles, *9* — throttle, *10* — measuring insert, *11* — dust sample container, *12* — dust feed control, *13* — collection ring for not entrained particles, *14* — thread of the mounting, *15* — angular delivery port between the fan panel and the body, *16* — dust feed head, *17* — stand, *18* — separation zone of the analyzer, *19* — rotor, *20* — fan working section, *21* — feed hopper outlet, *22* — container adjusting screw, *23* — brake, *24* — adjustment, *25* — throttle adjustment. *26* — locking screw, *27* — dust feed control valve.

In the Bahco analyzer used in the experiments the series of equivalent diameters was: d_e = 3.7, 7.0, 11.5, 16.0, 22.5, 32.5, 42.5, and 50.0 μm. This corresponds to the following dust settling rates in air at 20°C and a pressure of 760 mm Hg: V_d = 0.0366, 0.146, 0.294, 0.763, 1.51, 3.15, 5.25, 7.45 cm/sec.

By the equivalent diameter d_e is meant a diameter of a sphere of a unit density of 1 g/cm³ the settling rate of which, under the force of gravity in stationary air under a pressure of 760 mm Hg and at a temperature of 20°C and a relative humidity below 50 percent, equals the settling rate of the particle under study.

The apparent diameter d_a corresponds to the diameter of a sphere of the same density as that of the dust under examination under standard conditions specified in the preceding definition, the settling rate of which equals the settling rate of an actual irregular dust particle that falls down in a laminar motion.

Experimental

First, the particle-size distribution of the dusts under study was determined for a quantity usually recommended [1]–[6]. The starting quantities of 10-g portions were weighed with an accuracy of $\Delta_m = 0.2$ mg. These quantities, named starting quantities as distinguished from reduced quantities that ranged from 10 to 5.0 g, were assumed to be vitiated with

Table 1

Results for the Blast-Furnace Dust of an Absolute Density of $\gamma_d = 3.24$ g/m³

Apparent diameter, d_a μm	Particle-size distribution for particular W_i weights, %						
	m_{10}	m_9	m_8	$m_{7.5}$	m_7	m_6	m_5
27.7–60.0	15.6	15.2	14.4	15.2	16.0	15.9	16.4
23.3–27.7	12.0	12.0	12.1	11.7	11.6	11.5	11.4
18.1–23.3	6.4	6.5	6.6	6.6	6.0	5.9	5.8
12.5–18.1	9.9	10.0	10.4	10.5	10.6	10.7	10.6
8.9–12.5	10.1	10.4	10.3	9.9	9.7	9.6	9.5
6.4–8.9	15.1	15.3	15.5	14.9	14.7	15.5	15.4
3.9–6.3	12.6	12.4	12.3	12.8	12.9	12.0	12.0
2.1–3.9	10.1	10.0	10.3	10.4	10.5	10.5	10.4
< 2.1	8.2	8.2	8.1	8.0	8.0	8.4	8.5

a minimum measuring error in virtue of [1]–[6] and as such could be used as a frame of reference for a detailed discussion of error of the results obtained with the reduced dust quantities. Subsequently, the particle-size distribution was determined in the reduced-quantity samples. A suitable difference between the successive reduced dust weights was thus found, so as not to exceed the measuring error with a simultaneous good reproducibility and resolution of the results. The best difference thus found was 1 g to meet satisfactorily the criteria assumed. Ultimately, the studies were carried out using the following successive starting quantities of the reduced dust weights: $m_9 = 9.0$, $m_8 = 8.0$, $m_{7.5} = 7.5$, $m_7 = 7.0$, $m_6 = 6.0$, $m_5 = 5.0$ g. If this difference is diminished the measuring error region is achieved which substantially impairs a correct interpretation of the results. The quantity of $m_{7.5}$ was additionally introduced after the discussion of

error had been made to demostrate that for the m_6–m_7 interval the results fall into the inadmissible error region for a probability of 0.95 assumed. Results of the experiments obtained are summarized in Tables 1 and 2 in the form of arithmetic means of three measurements for each interval of apparent diameters d_a for individual weights from m_{10} to m_5.

The values of the absolute densities given were obtained from a gas pycnometer determinations [5], [9]–[11]. All the results of the percent weight shares W_i attained for successive weights in the m_{10}–m_5 range are reported in Table 1 for illustration for the blast-furnace dust. Meanwhile

Table 2

Particle-Size Distribution for the W_i Weights of the Dust Samples Examined, %

Sample	Apparent diameter, d_a μm	m_{10}	$m_{7.5}$	m_5
Feldspar powder				
γ_d = 2.60 g/cm³	31.0–60.0	16.2	15.2	11.3
	26.1–31.0	2.4	2.3	3.8
	20.2–26.1	5.1	4.8	6.8
	13.9–20.0	11.9	12.6	13.3
	9.9–13.9	12.9	12.2	11.0
	7.1–9.9	15.6	16.6	13.6
	4.3–7.1	12.9	12.2	14.8
	2.2–4.3	13.3	14.1	14.6
	< 2.2	9.5	10.0	10.8
Portland cement grade 250				
γ_d = 3.10 g/cm³	28.1–60.0	26.8	28.7	30.1
	23.7–28.1	5.3	4.4	4.0
	18.3–23.7	9.2	10.0	8.2
	12.7–18.3	16.0	15.0	14.6
	8.9–12.7	13.5	12.8	12.2
	6.4–8.9	15.7	14.9	14.3
	3.9–6.4	9.3	8.4	10.5
	1.9–3.9	2.7	3.5	3.7
	< 1.9	1.5	2.3	2.4
PVC plant dust				
γ_d = 1.76 g/cm³	36.8–60.0	1.2	1.5	2.4
	30.9–36.8	1.3	1.8	2.4
	23.9–30.9	5.7	5.0	6.9
	16.6–23.9	18.4	17.0	16.9
	11.8–16.6	21.9	22.9	23.0
	8.5–11.8	22.0	23.1	23.5
	5.2–8.5	14.1	13.2	11.6
	2.6–5.2	9.2	10.0	8.1
	< 2.6	6.2	5.3	8.2

Table 2 lists the results of W_i obtained for the remaining samples only for the most characteristic result — that is, for m_{10}, $m_{7.3}$, and m_5. For the remainder of the results not reported similar relations were obtained as for the blast-furance dust (Table 1).

Results

The percent weight share of individual fractions of particle-size distribution as a function of the air flow rate and for a given range of apparent diameters was evaluated from relation

$$W_i = \frac{m_1 - m_2}{m} 100\% \tag{6}$$

where

m — is the starting weight,

m_1 — is the starting weight of the dust sample for a given air flow rate.

m_2 — is the dust weight upon centrifugation at the same air flow rate.

For the first centrifugation, $m = m_1 = 10$ g and, alternatively, for other quantities of the dust used, $m = m_1 = 10$–5 g. For the second centrifugation $m_1 = m_2$ (that is, the quantity resulting after the first centrifugation), for the third successive centrifugation $m_1 = m_2$ (the quantity obtained after the second centrifugation), and so forth.

Table 3

Results of Recalculation of the Values Obtained for $m = 6.0$ g to m_6 after Relations (7)–(9) for Feldspar Powder

Apparent diameter, d_a μm	W_6 %	$m_6 = \frac{W_6}{60} 100\%$
31.0–60.0	7.2	12.0
26.1–31.0	1.9	3.2
20.2–26.1	4.1	6.9
13.9–20.2	7.8	13.0
9.9–13.9	6.8	11.3
7.1–9.9	8.2	13.6
4.3–7.1	8.8	14.7
2.2–4.3	8.7	14.5
< 2.2	6.5	10.8
	$\sum = 60.0$	$\sum = 100.0$

Besides, the results obtained with the use of starting weights m_6–m_5, listed in Tables 1 and 2, are, for their better comparison, recalculated from

the starting weights ratio, m_9–m_5 (90–50 percent)*to m_{10} = 10 g (100 percent), from the relation

$$m_9 = \frac{W_9}{90} 100\% \tag{7}$$

$$m_8 = \frac{W_8}{80} 100\% \ldots\ldots \tag{8}$$

$$m_5 = \frac{W_5}{50} 100\% \tag{9}$$

An example of the recalculation of individual values obtained for m = = 6.0 g into m_6 after relations (7–9) is given in Table 3.

The m_6 values thus calculated, as well as those found for m_9 to m_5 for individual dust kinds examined (see Tables 1 and 2), enabled a discussion of error to be made for the same 10-g quantity rather than for the actual starting quantities used in the particle-size distribution measurements.

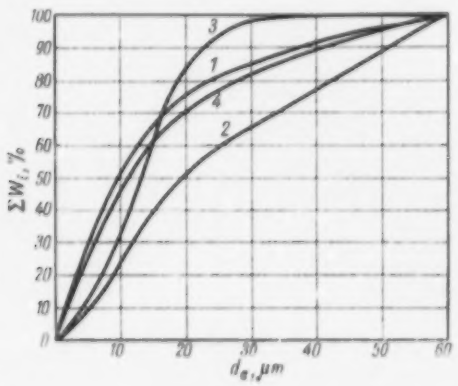

Fig. 3. Plot of ΣW_i vs. d_a: *1* — feldspar powder, *2* — Portland cement grade 250, *3* — PVC plant dust, *4* — blast-furnace dust.

For a better illustration of the results obtained the total weight share ΣW_i is plotted against apparent diameter d_a for the dusts examined in Fig. 3. For the blast-furnace dust and the feldspar powder the ΣW_i vs. d_a relations have a very close run. For the Portland cement instead, the $\Sigma W_i = f(d_a)$ curve has a smooth run along its whole extension and below the curves *1* and *4*. On the other hand, curve *3* differs from the others by a sharp increase in ΣW_i up to 95 percent in the range 0–25 μm to become flat up to 100 percent above that range.

Discussion of Error

Discussion of error was conducted in two stages. Two quantities (the starting and the reduced ones) were compared for the same weights m after relation

$$\delta = \frac{|A_{av} - a_{av}|}{A_{av}} 100\% \tag{10}$$

where

A_{av} — is the starting average quantity,

a_{av} — is the reduced average quantity.

Moreover, a statistical estimation was carried out in relation to the reduced average quantities whether or not these are random values at a probability of 0.95. The statistical estimation was made to reject or to accept the values achieved regardless of the δ value.

For a statistical verification of the reduced average the t-Student test was used [7], [8]

$$\frac{|\bar{x} - m|}{S(\bar{x})} \tag{11}$$

where

$\bar{x}$ — is the reduced average quantity,

m — is the true starting average quantity,

$S(\bar{x})$ — is a function dependent on the number of measurements.

The $S(\bar{x})$ function denotes standard deviation of the averages of the samples of an n size taken from a population whose standard deviation is $S(x)$, and

$$S(\bar{x}) = \frac{S(x)}{\sqrt{n}} \tag{12}$$

where

$$S(x) = \sqrt{\frac{\Sigma' x^2}{n-1}} \tag{13}$$

$$\Sigma' x^2 = \Sigma x^2 - \bar{x}\,\Sigma x = \sum_{i=1}^{n} (x_i - \bar{x})^2 \tag{14}$$

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{15}$$

Ultimately, the statistical soundness of the reduced average quantity was calculated from a relation

$$t_1 = \frac{|\bar{x} - m|}{S(\bar{x})\sqrt{\frac{1}{n}}} \tag{16}$$

For a statistical comparison of the reduced average quantity with the starting average quantity also the t-Student test was applied

$$t_2 = \frac{|\bar{x}_1 - \bar{x}_2|}{S(x)\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \tag{17}$$

where

$\bar{x}_1$ and $\bar{x}_2$ — two separate averages,

n_1 and n_2 — the number of samples from which $\bar{x}_1$ and $\bar{x}_2$ are respective averages,

$\bar{S}(x)$ — totally estimated standard deviation from both sets.

The $S(x)$ value is calculated from the relation

$$\bar{S}(x) = \sqrt{\frac{\Sigma' x_1^2 + \Sigma' x_2^2}{n_1 + n_2 - 2}} \tag{18}$$

The t_1 and t_2 values obtained (Table 4) are compared with the t value at a confidence level of 0.05 which for $n = 3$ — that is, for two degrees of freedom amounts to $t_{0.05} = 4.303$.

For the remaining dust samples the t_1 and t_2 values obtained exhibit the same relations.

Table 4

The $t_{0.05}$ Values for the Blast-Furnace Dust in Statistical Estimation of the Reduced Average Quantity and for Comparison with the Starting Quantity Average

Apparent diameter, d_a μm	t_1 and t_2	m_9	m_8	$m_{7.5}$	m_7	m_6	m_5
27.7–60.0	t_1	1.526	2.047	4.175	4.594	6.324	7.385
	t_2	1.478	1.823	2.984	4.375	5.243	7.080
23.3–27.7	t_1	1.526	2.705	3.976	5.707	7.538	6.654
	t_2	1.478	2.401	2.982	5.293	6.479	5.882
18.1–23.3	t_1	2.430	2.645	6.404	7.324	6.945	7.909
	t_2	2.100	2.225	5.750	6.175	5.204	7.073
12.5–18.1	t_1	1.954	3.409	4.294	6.491	9.805	8.433
	t_2	1.631	3.143	3.515	6.008	7.500	7.991
8.9–12.5	t_1	2.047	3.573	4.103	5.500	10.054	7.500
	t_2	1.906	3.247	3.054	4.708	7.500	6.384
6.4–8.9	t_1	2.500	4.295	4.705	6.324	8.304	8.109
	t_2	1.871	3.998	4.456	5.889	7.252	7.352
3.9–6.4	t_1	2.426	2.724	3.928	7.324	6.373	6.421
	t_2	2.200	2 501	3.177	5.792	5.821	6.048
2.1–3.9	t_1	2.012	3.505	7.204	4.803	6.405	9.450
	t_2	1.674	3.121	5.100	4.349	5.792	8.750
< 2.1	t_1	3.357	2.964	4.705	5.028	4.957	5.988
	t_2	3.208	2.625	3.982	4.807	4.505	5.305

Discussion of the Results

From comparison of the starting average quantity with the reduced average quantity at the same intervals of the apparent diameters d_a and at the same weights m after relation (10), a δ value range was obtained as 0.9 to 12 percent over the whole range of the starting weights employed for the dusts examined. Generally, for each weight (m_9–m_3) used the δ value was on average 2 percent higher. Statistical estimation of the soundness of the reduced average quantity from relation (16) and a statistical comparison of the starting and the reduced average quantities after relation (17) shows that:

— for the feldspar powder the t_1 and t_2 values achieved are lower than 4.303 for weights m_9, m_8, and $m_{7.5}$, and partly also for m_7. For weights m_6 and m_5 the t_1 and t_2 values are higher than 4.303,

— for the Portland cement grade 250 the t_1 and t_2 values are lower than 4.303 for weights m_9 and m_8, and partly for $m_{7.5}$. For weights m_7, m_6, and m_5 the t_1 and t_2 values are higher than 4.303,

— the findings for the PVC plant dust and for the blast-furnace dust are analogous to the data noted for the Portland cement.

On the basis of a further comparison of the results of the statistical estimation of the averages at a probability level assumed, it may be generalized that the results obtained with the use of the starting dust quantities down to $m_{7.5}$ inclusive remain within the limits of admissible error of measurement. A further reduction in weight of the samples from $m_{7.5}$ to m_5 results in an increased scatter of the experimental points of the determinations. Likewise, the t_1 and t_2 quantities exhibit higher values in excess of 4.303, which obviously indicates that they have to be rejected on the grounds of their falling off the admissible error range.

Additionally, a satisfactory reproducibility of the results obtained was noticed for individual values of the apparent diameters at a given air flow rate V_a. This observation was confirmed by the finding that the difference between individual results at various V_a and d_a values, and their arithmetic mean for a given dust does not exceed 7 percent for weights $m \geqslant 7.5$ g. It also follows from the discussion of error made that the scatter between individual results and their arithmetic mean, which equals 7 percent, is not an accidental value.

A conclusion can, therefore, be made that if as large a quantity as 10 g of the dust sample is unavailable, but the quantity possessed is not lower than 7.5 g, a successful particle-size analysis can be made using a Bahco analyzer, and the results of the analysis would remain within the limits of admissible error.

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KINETICS OF THE SULFUR DIOXIDE ABSORPTION IN ALKALINE SOLUTIONS

(Kinetyka absorpcji dwutlenku siarki w roztworach alkalicznych)

The effect of the initial SO_2 concentration in air on the SO_2 absorption rate was studied in sodium hydroxide, sodium carbonate, sodium hydrogen carbonate, and sodium sulfite solutions. The effect of the SO_2 concentration, gas flow rate, absorption liquid spraying rate, and temperature on the SO_2 absorption rate from gases of a composition which is equivalent to that of real flue gases, in a sodium hydroxide solution, was also investigated. The presence of CO_2 in flue gases was found to have no effect on the SO_2 absorption coefficients in NaOH solution.

The dolomite-limestone method of the sulfur dioxide removal from flue gases has become more attractive today in view of a novel modification advanced which provides recovery of free sulfur and recycling of calcium compounds [1]. The modification developed for liquid-fuel fired boilerhouses involves the following processes and operations. Crushed limestone is added into the fuel and the resultant slurry is fed into the boiler furnace. In the furnace the limestone calcines and some of the SO_2 present becomes fixed. Next, the gases pass into scrubber 1 which works primarily as a dust collector. Sludge from that scrubber, which contains lime, is fed into a causticizer. Spent scrubbing solution, which includes Na_2SO_3 and $NaHSO_4$ from scrubber 2, is also fed into the causticizer. Scrubber 2 is fed with an NaOH solution produced in the causticizer to trap the remaining SO_2 from the gases. The following reaction occurs in the causticizer

$$Na_2SO_3 + Ca(OH)_2 = 2NaOH + CaSO_3$$

The $CaSO_3$ thus formed, which is partly oxidized to $CaSO_4$, may be reduced to CaS. Subsequent process involves carbonation of CaS in the reaction

$$CaS + CO_2 + H_2O = CaCO_3 + H_2S$$

The calcium carbonate produced may be recirculated into the process, and the hydrogen sulfide may be oxidized by the Claus technique to free sulfur.

The objective of this study was to gain some information on the course of the SO_2 absorption process in a variety of alkaline solutions from gaseous mixtures artificially prepared, whose composition simulates that of real flue gases from boilers of power plant steam generators. Another secondary objective of the study was to investigate the effect of the presence of CO_2 in flue gases on the SO_2 absorption rate from these gases. The data achieved should be helpful in further research on this process along the lines of improvement on the design of the scrubber 2 in the dolomite-limestone technique under consideration.

The following may be inferred from a review of the pertinent literature on the SO_2 absorption kinetics from SO_2–air mixture by alkaline solutions of NaOH, Na_2CO_3, or NH_4OH.

— The mass transfer coefficient in a variety of aqueous alkaline solutions was found [2] to be independent of the initial SO_2 concentration in a range of 0.08 to 3.5 percent by volume. At higher SO_2 concentrations chemically nonbonded SO_2 appears in the liquid which impairs the absorption rate. Under such conditions the rate-determining step of the absorption process is the SO_2 hydration [2], [3]

$$(SO_2)_{aq} + H_2O = H_2SO_3$$

— There is a certain critical value of the absorbent concentration above which the absorption rate depends only on the gas phase resistance. Below the critical value of the absorbent concentration the absorption process is controlled by resistances in the gaseous and liquid phases [4], [5].

— The temperature has a minor effect on the SO_2 absorption in sodium hydroxide solutions. With increasing temperature the mass transfer coefficient slightly decreases [6].

— Since the flue gases delivered to the second stage absorption in the method in point contain a 20-fold excess of CO_2 with respect to SO_2, a considerable part of the sodium hydroxide used in the scrubbing solution will expectedly react with CO_2 to form sodium hydrogen carbonate and sodium carbonate [7]. For that reason the research project included also experiments with the latter compounds.

Experimental

The experiments were carried out in a conventional absorption apparatus in the form of a thermostated tube whose inside walls are sparged with an absorbing liquid, and dimensions: I.D. = 0.017 m, length 0.38 m.

The first part of the study included the reproduction of the experiments made by Chertkov [2] concerned with the effect of the SO_2 concentration in the initial gaseous mixture composed of air and SO_2 on the mass transfer coefficient of the absorption process in an NaOH solution. The experiments were additionally extended over the SO_2 absorption from air in sodium carbonate and sodium hydrogen carbonate solutions. Moreover, the effect of SO_2 in SO_2–air mixture on the absorption rate in a sodium sulfite solution was investigated. The latter experiments were of interest, as scrubber 2 is to be sparged with recirculated sodium sulfite solution with an addition of sodium hydroxide from the causticizer. No data is available in the literature on the SO_2 absorption kinetics in sodium hydrogen carbonate and sodium sulfite solutions.

In the studies made only the SO_2 concentration in the air was varied from 0.12 to 0.50 percent by volume. The remaining parameters were maintained at a constant level. Values of these parameters were: gas flow rate — 100 dm^3/hr, sparging rate — 1.80 dm^3/hr, absorbent concentration — NaOH, Na_2CO_3, $NaHCO_3$, Na_2SO_3 — 0.1 equiv./dm^3, temperature — 25°C.

In the second part of the study sulfur dioxide was absorbed from a gas of a composition which corresponded to real flue gases. The content of particular components of that gas was: N_2 — 83.0 percent, O_2 — 5 percent, CO_2 — 11.2 percent, SO_2 — 0.4 percent by volume. The effect of such parameters was studied as the initial SO_2 concentration in flue gases, gas flow rate, sparging rate, and temperature on the SO_2 absorption rate in a 0.1N NaOH solution. The parameters that were kept constant were on the same level as in the first part of the experiments.

The mass transfer coefficients were calculated on the basis of the iodometric determinations of SO_2 in the gas before and past the reactor, and of a complete analysis of the solutions upon absorption. The analysis of the solutions comprised determinations of SO_3^{2-}, HSO_3^-, SO_4^{2-}, OH^-, CO_3^{2-}, and pH value of the solution. The coefficients were evaluated from the relation [8]

$$K_{SO_2} = \frac{M_{SO_2}}{F_2 \, \Delta p_m}$$

where

K_{SO_2} — the mass transfer coefficient, mol/m^2·hr mm Hg,
M_{SO_2} — the quantity of the SO_2 absorbed, mol/hr,
F_2 — the mass transfer surface area, equal to 0.203 m^2,
Δp_m — the driving modulus of the absorption, mm Hg.

The mean absorption driving modulus Δp_m was evaluated from the formula

$$\Delta p_m = \frac{\Delta p_1 - \Delta p_2}{2.3 \log \frac{\Delta p_1}{\Delta p_2}} \text{ mm Hg}$$

where

$\Delta p_1 = p'_{SO_2} - p^{*'}_{SO_2}$,

$\Delta p_2 = p''_{SO_2} - p^{*''}_{SO_2}$,

p'_{SO_2} — the partial pressure of SO_2 in the gas at the inlet to the absorption apparatus, mm Hg,

$p^{*'}_{SO_2}$ — the equilibrium pressure of SO_2 over the absorbing solution, mm Hg,

p''_{SO_2} — the partial pressure of SO_2 in the gas at the outlet from the absorption apparatus, mm Hg,

$p^{*''}_{SO_2}$ — the equilibrium pressure of SO_2 over the liquid that enters the absorption apparatus, mm Hg.

In conformity with the conclusions made in [9]

$$p^{*'}_{SO_2} = 0, \quad p^{*''}_{SO_2} = 0$$

fro all the measurement series.

Discussion of the Results

Results of series I and II proved the legitimacy of the major conclusions made from the studies by Chertkov, notably no effect of the SO_2 concentration on the mass transfer coefficient, and that absorption in Na_2CO_3 solution proceeds at a slightly higher rate than in NaOH solution

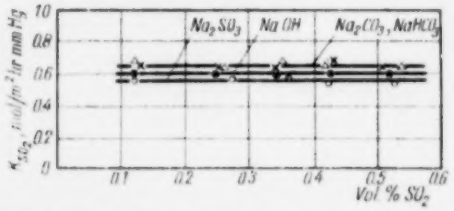

Fig. 1. The effect of the initial SO_2 concentration in the air on the mass transfer coefficient in NaOH, Na_2CO_3, $NaHCO_3$, and Na_2SO_3 solutions.

(Fig. 1). Basing on the results of the experimental series III, conducted under the same conditions as series I and II, it was demonstrated (Fig. 1) that the SO_2 absorption rate from the air for SO_2 concentration ranging 0.1–0.52 percent by volume in a 0.1N $NaHCO_3$ solution is constant and very

close to the absorption rate in a corresponding Na_2CO_3 solution. It was, thereby, demonstrated that the presence of CO_2 in flue gases should not impair the SO_2 absorption rate in NaOH or Na_2CO_3 solutions. This inference is substantiated by results of an experimental series performed using a gas of a composition similar to that of flue gases at the parameters as in series I, II, and III (Fig. 2). It was also shown in Fig. 1 that the initial

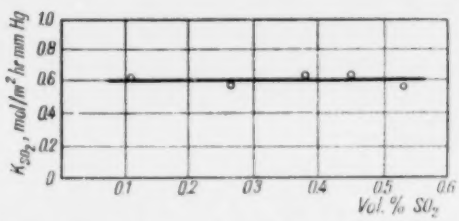

Fig. 2. The effect of the initial SO_2 concentration in flue gases on the mass transfer coefficient in NaOH solution.

SO_2 concentration in the air has no effect on the absorption rate in a 0.1N Na_2SO_3 solution. Here the mass transfer coefficients have slightly lower values than for the absorption in NaOH, Na_2CO_3, and $NaHCO_3$ solutions.

Results of the second part of the study indicate that in the $(Re)_g$ range examined the resistance in the absorption process is likely on the gas side. In order to separate the overall mass transfer coefficient into the resistances offered by particular phases a graphic method that results from the similarity theory was used [8]. Results of the experimental series in which the gas flow rate was varied from 63.8 to 143.3 dm³/hr (a range of varia-

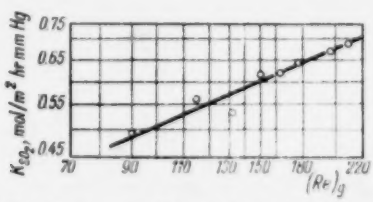

Fig. 3. The effect of the flue gases flow rate on the mass transfer coefficient.

tions of $(Re)_g$ from 91.0 to 214.0) are presented as a function of $(Re)_g$ in a log-log scale in Fig. 3. The plot represents a line of a slope $n = 0.398$. Relation $1/K_{SO_2}$ vs. $1/(Re)_g^n$ illustrated in Fig. 4 constitutes a line passing through the origin of the coordinate system which indicates that the absorption resistance is likely only on the gas side. This conclusion is confirmed by the subsequent series of experiments carried out under

conditions of a stationary gas flow and a variable liquid flow (the rate ranging 1.80–5.83 dm³/hr). As seen in Fig. 5, the values of the mass transfer coefficient as a function of $(Re)_g$ plotted in a logarithmic scale fall on a line that runs parallel to the abscissa axis. This would point to a con-

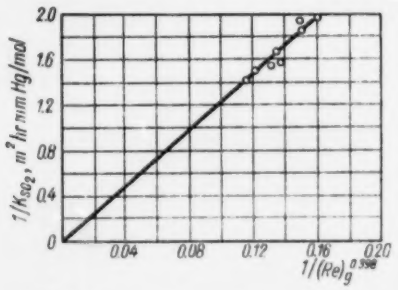

Fig. 4. Determination of the mass transfer coefficient on the liquid side.

clusion that under conditions of the experiments conducted the absorption resistance in the liquid is negligible. The SO_2 absorption process from flue gases in an NaOH solution is, therefore, controlled by the diffusion resistance of the gas phase.

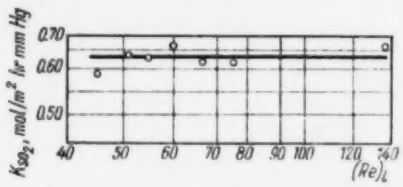

Fig. 5. The effect of the sparging rate on the mass transfer coefficient from flue gases.

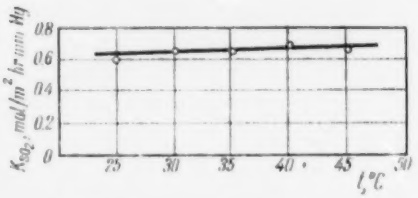

Fig. 6. The temperature effect on the mass transfer coefficient in NaOH solution.

Results of the studies of the temperature effect on the SO_2 absorption rate in a 0.1N NaOH solution are shown in Fig. 6. In the temperature range examined (25.0 to 45.0°C), the temperature has no effect on the SO_2 absorption rate from the gas mixtures studied in NaOH solutions.

Conclusion

1. The presence of CO_2 in flue gases has no effect on the value of the SO_2 absorption coefficient in a 0.1N NaOH and Na_2CO_3 solutions. Value of this coefficient was found to be the same as for absorption of SO_2 from the air.

2. Values of the absorption coefficient in alkaline solutions of NaOH, Na_2CO_3, $NaHCO_3$, and Na_2SO_3 are independent of the initial SO_2 concentration in the gas over a range of about 0.1 to about 0.5 percent by volume.

3. In the laminar flow range of the gas and of the liquid the absorption coefficients vary only along with the changed hydrodynamic conditions of the gas after relation $K_{SO_2} = C \cdot Re^{0.88}$.

4. In the range examined the absorption resistance in the liquid phase (in a 0.1N NaOH solution) vanishes completely.

5. The presence of CO_2 in flue gases has no effect on the previously determined [6] temperature dependence of the absorption rate. The values of the absorption coefficients for various temperatures remain constant.

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GASEOUS EFFLUENTS TREATMENT BY ADSORPTION TECHNIQUE CALCULATION OF THE REQUIRED ADSORBENT BED HEIGHT

(Oczyszczanie gazów odlotowych metodą adsorpcji — obliczanie niezbędnej wysokości warstwy adsorpcyjnej)

Methods for evaluation of the adsorbent bed height in industrial adsorbers designed for gaseous effluents treatment are reviewed. Both the analytical approaches and a model method are discussed.

The adsorption process is a widespread technique used in industry for gaseous effluents treatment. This technique is applied for the removal of water vapor, vapors of organic solvents, gaseous hydrocarbons, odors, toxic compounds, and the like [1]. During the adsorption process the substance trapped is accumulated on the surface of an adsorbent, a solid of a highly developed surface. Adsorbents commonly used have a microporous structure and a specific surface up to 10^6 m²/kg. Adsorbent materials are usually pelletized of a grain size not exceeding a few millimeters [1], [2]. For drying gases the adsorbents used contain silica or alumina, whereas for the removal of vapors of organic solvents activated carbon is generally employed. An important group of adsorbents of a structure of porous crystals is known as molecular sieves which are suitable for selective adsorption both in drying gases and in trapping other individual compounds.

Effluent treatment in manufacturing plants is usually effected by passing waste gases to be cleaned through a stationary adsorbent bed. In the apparatus of that kind the process conditions are not established since the adsorption zone is constantly moving during the process in the direction of the gas flow. This fact makes a mathematical treatment of the process much more difficult so that designing the adsorption process which consists in a suitable selection of the adsorbent bed height, is often based on exclusively empirical data.

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In view of considerable problems with determination of concentration of the adsorbate in a stationary adsorbent both in the studies on the mass transfer mechanism and in designing the process, a concept of the breakthrough curve has been found convenient. The curve provides the adsorbate concentration in the gas stream which comes out of the fixed bed as a function of the process time. The appearance of the adsorbate in the gas which leaves the bed in a concentration corresponding to an *a priori* assumed level represents a breakthrough point on the curve.

Basic data, needed for the process balance calculations, is provided by the findings from the sorption equilibrium studies. In view of the complexity of theoretical problems related to the adsorption equilibrium, especially for multicomponent systems of considerable practical interest [2]–[4], usually the theoretical generalizations that are incomplete are given up to be replaced by direct experimental data. Of assistance here are the dynamic methods of determination of the adsorption equilibrium described in the papers mentioned [2], [3] or in relevant standards [5].

A general equation of the breakthrough curve in a simple mathematical form is not easy to derive since the sorption equilibrium usually represents a nonlinear relation (it will be remembered that Brunauer [6] distinguishes five major types of the sorption isotherm). Similarly, no conclusion can be drawn as to the equilibrium of the system from the run of the breakthrough curve, even if it may be expected that the curve is described by a simple equation.

The available mathematical solutions, based on the equilibrium isotherms and the mass transfer coefficients known, were developed with a number of simplifying assumptions. Commonly a linear equilibrium is assumed or a simple type of a "desirable" equilibrium (for instance, type I after Brunauer), and the effect of longitudinal dispersion in the bed, and one of the diffusion resistances — that is, internal or external diffusion. In a general case the methods based on model studies on a small scale are employed. A brief review of the designing methods in current use will follow below.

Analytical Methods

As mentioned previously, analytical solutions can only be derived upon suitable simplifying assumptions. The oldest solutions [8], [9] were achieved for a linear equilibrium isotherm assumed of the form

$$y_e = mz$$

where

y_e — the mole fraction of the adsorbate in the gaseous phase (under equilibrium conditions),

z — molar concentration of the adsorbate in the solid phase,

m — the equilibrium constant.

Assuming that the system is dilute and the longitudinal dispersion is ignored, a balance equation for the adsorbate can be written for a differential section of the bed of a height dh in the form

$$Gy\,d\tau = G\left[y+\left(\frac{\partial y}{\partial h}\right)dh\right]d\tau+(1-\varepsilon)\left(\frac{\partial z}{\partial \tau}\right)dh\,d\tau+\varrho_M\varepsilon\left(\frac{\partial y}{\partial \tau}\right)dh\,d\tau \tag{1}$$

where

G — the gas flow rate,

h — adsorbent bed height,

y, z — adsorbate concentration in the gaseous and liquid phases, respectively, defined as before,

ε — porosity of the adsorbent bed,

τ — time,

ϱ_M — gas molar density.

In the above equation the left side represents the adsorbent quantity that reaches the bed section under consideration in a time unit, the first right-side term refers to the adsorbate quantity that leaves that bed section, the second term corresponds to the adsorbate quantity accumulated in the bed section in point in the solid phase (that is, the adsorption rate), finally the last term accounts for the adsorbate quantity accumulated in the gaseous phase.

After suitable rearrangement Eq. (1) may be written in the form

$$-G\left(\frac{\partial y}{\partial h}\right)=(1-\varepsilon)\left(\frac{\partial z}{\partial \tau}\right)+\varrho_M\varepsilon\left(\frac{\partial y}{\partial \tau}\right) \tag{2}$$

Since the adsorption rate may alternatively be expressed by a kinetic equation

$$(1-\varepsilon)\left(\frac{\partial z}{\partial \tau}\right)=K_y a(y-y_e) \tag{3}$$

where

$K_y a$ — the volume mass-transfer coefficient,

y_e — equilibrium adsorbate concentration in the gaseous phase,

whereas the accumulation of the adsorbate in the gaseous phase for most practical cases is negligible, we will have

$$\frac{\partial z}{\partial \tau}=\frac{G}{(1-\varepsilon)H_{oy}}(y-y_e)$$
$$\frac{\partial y}{\partial h}=-\frac{1}{H_{oy}}(y-y_e) \tag{4}$$

where

$H_{og} = G/K_y a$ — is the mass-transfer unit height related to the gaseous phase.

The above system of partial differential equations may be solved using the linear equilibrium isotherm for boundary conditions [8], [9]

$$\begin{aligned} y &= y_o \quad h = 0 \quad \tau > 0 \\ z &= z_o \quad h > 0 \quad \tau = 0 \end{aligned} \tag{5}$$

Then a solution is obtained in the form

$$\frac{y - y_{eo}}{y_o - y_{eo}} = 1 - e^{-Bm\tau} \int_0^{Ah} e^{-Ah} I_o(2i\sqrt{Bm\tau Ah}) d(Ah) \tag{6}$$

$$\frac{z - z_o}{z_{eo} - z_o} = e^{-Ah} \int_0^{Bm\tau} e^{-Bm\tau} I_o(2i\sqrt{Ah\, Bm\tau}) d(Bm\tau) \tag{7}$$

where

$y_{eo} = mz_o$, $z_{eo} = y_o/m$,

y_o — the adsorbate concentration in the incoming gas,

z_o — the initial adsorbate concentration in the solid adsorbent,

I_o — the Bessel function of the first kind, of the zero order,

$A = 1/H_{og}$,

$B = G/(1-\varepsilon)\, H_{og}$,

i — immaginary unit.

Assumptions like those used in the example discussed above were also applied by other authors [10]–[15]. Solutions of that kind, commonly given in a graphical form for their easier use, are suitable for the determination of the adsorbate concentration in the gaseous and liquid phases at any instant and at any point to the bed, thus also for a plot of the breakthrough curve. The course of the equilibrium isotherm and the values of the mass-transfer coefficients on the gas and the solid sides must, however, be known here.

The solutions in question are seldom used in practice, as there are few real systems to meet the simplifying assumptions made. This particularly can be said of the assumption of a linear course of the equilibrium isotherm. A nonlinear equilibrium isotherms are observed for such important systems as benzene–activated carbon, acetone–activated carbon, and others. For that reason the authors of later solutions made attempts to substitute this assumption by another, more often met in practice, such as the assumption of a simple mathematical form of a "desirable" (that is, convex downward) run of the equilibrium isotherm $y = f(z)$ (see for instance [16]–[20]).

An instance of a good procedure in that case is a recent investigation by Ikeda et al. [7]. This procedure will be treated below.

On the assumption of isothermal conditions and dilution of the system (as well as approximately constant density of the gaseous phase) the following form will be achieved for the balance of the adsorbate for a differential bed height dh

$$-E\varepsilon \frac{\partial_c^2}{\partial h^2} + u\varepsilon \frac{\partial c}{\partial h} + \varepsilon \frac{\partial c}{\partial \tau} + (1-\varepsilon) \frac{\partial z}{\partial \tau} = 0 \tag{8}$$

where

E — the longitudinal dispersion coefficient,
ε — porosity of the adsorption bed,
h — the bed height,
c — the adsorbate concentration in the gas,
z — the adsorbate concentration in the solid,
u — the gas flow rate,
τ — time.

The first term of the above equation refers to the inflow of the adsorbate (net quantity) into the adsorbent bed section considered, caused by the longitudinal dispersion, the second term is related to the inflow of the adsorbate with the passing inert gas (mass convection), the third term is responsible for the accumulation of the adsorbate in the gaseous phase, whereas the last term corresponds to the accumulation of the adsorbate in the solid phase (adsorption rate). The adsorption rate may, of course, be expressed by a kinetic equation

$$(1-\varepsilon) \frac{\partial z}{\partial \tau} = k_c a(c - c_i) = k_s a(z_i - z) \tag{9}$$

where

k_c — the mass-transfer coefficient on the gas side,
k_s — the mass-transfer coefficient on the solid side,
a — interface area,
c_i, z_i — the adsorbate concentration at the interface in the gas and in the solid, respectively.

Upon assumption of a certain form of the equilibrium isotherm

$$z_i = f(c_i) \tag{10}$$

the set of Eqs. (8) and (9) can be solved analytically or numerically for specific boundary conditions, to obtain relations

$$\begin{aligned} c &= f_1(h, \tau) \\ z &= f_2(h, \tau) \end{aligned} \tag{11}$$

which enable the adsorbate concentration to be determined at any instant and at any point of the adsorbent bed.

The authors of the study mentioned [7] found the solutions for two cases:

(a) a numerical solution on the assumption that the equilibrium isotherm may be described by the Langmuir equation in the form

$$z_i = \frac{Kz_\infty c_i}{1 + Kc_i} \tag{12}$$

where

K and z_∞ — constants characteristic of the system;

(b) an analytical solution on the assumption that the equilibrium isotherm may be replaced by two lines tangential to the isotherm at points $c = O$ and $c = c_o$ and intersecting at point c_a, z_a. Here the equilibrium line can be represented by formulas

$$z_i = \frac{z_a}{c_a} c_i \quad \text{for} \quad O \leqslant c_i \leqslant c_a \tag{13}$$

and

$$z_i = \frac{z_{eo} - z_a}{c_o - c_a}(c_i - c_a) + z_a \quad \text{for} \quad c_a \leqslant c_i \leqslant c_o \tag{14}$$

These solutions describe a number of analytical relations which represent function (11) for the following cases of the diffusion resistances distribution:

(a) the diffusion resistances prevail on the gas side,

(b) the diffusion resistances prevail on the solid side,

(c) the diffusion resistances in both phases are comparable.

For illustration we will present the form of the analytical solution achieved for case (b) and a concentration range $O \leqslant c_i \leqslant c_a$. The solution is given by the following equations

$$c = c_a \exp r_1(h - \varkappa\vartheta) \tag{15}$$

$$z = z_{eo} \frac{c_a}{c_o}(1 - r_1\varkappa) \exp r_1(h - \varkappa\vartheta) \tag{16}$$

where

$$r_1 = \frac{1}{2}\varkappa\left[1 + \eta - \sqrt{(1-\eta)^2 + 4\eta z_a c_o / c_a z_{eo}}\right] \tag{17}$$

$$\varkappa = E(1+\delta)/u\delta \tag{18}$$

$$\vartheta = u^2\delta\tau/(1+\delta)^2 E \tag{19}$$

$$\eta = k_s a E(1+\delta)^2 c_o / u^2\delta(1-\varepsilon)^2 z_{eo} \tag{20}$$

$$\delta = \frac{(1-\varepsilon)z_{eo}}{\varepsilon c_o} \tag{21}$$

Apparently, the form of the function of the breakthrough curve is rather involved despite that the relation for the equilibrium isotherm is fairly simple.

Comparison of the numerical solution obtained on the assumption of the Langmuir isotherm with the analytical solution achieved by substitution of the equilibrium isotherm with two tangents to the isotherm at its both ends, showed a good agreement of the results obtained by either method. Likewise, comparison of the results of calculations with experimental data indicates a reliability and a high accuracy of the calculations. The experimental results obtained as breakthrough curves for the systems: propane–molecular sieve, benzene–activated carbon, and acetone–activated carbon are illustrated in Figs. 1 and 2. Thus the method

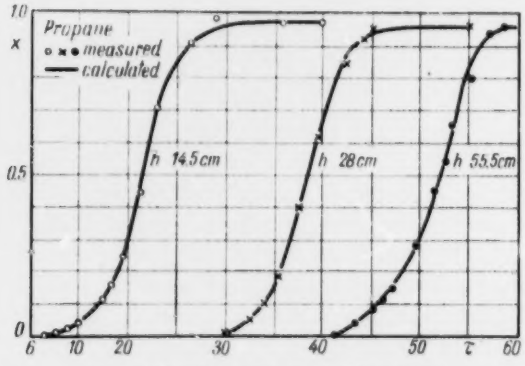

Fig. 1. Adsorption on molecular sieves.

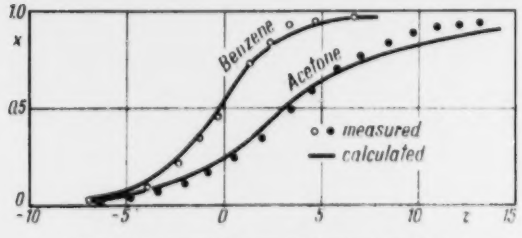

Fig. 2. Adsorption on activated carbon.

proposed by Ikeda et al. [7] is suitable for calculation of the adsorbent bed height in the case of a "desirable" run of the equilibrium isotherm.

Model Methods

As mentioned previously, in a general case of determination of the adsorbent bed height use is made of results of the measurements of a model process. In accordance with the principles of increasing the scale of

processes running in porous beds, the results obtained in laboratory can be used in practical calculations, provided a suitable ratio of the column diameter to the grain diameter is maintained (the ratio should exceed 10). The experimental bed is actually regarded as a section of the bed of a large-scale absorption apparatus.

Some advantages along the lines of successful transferring of results of the measurements to the beds of a different height can be gained from the use of a method developed by Michaelis [21], [22]. This is a simplified method based on the concept of a constant adsorption zone height — that is, on the assumption that in the absorption process, under isothermal conditions for dilute systems of a "desirable" equilibrium, the adsorption zone height is roughly constant during the migration of the adsorbate.

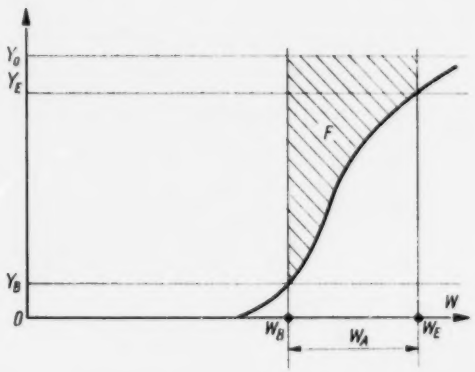

Fig. 3. Diagram of the breakthrough curve run.

The Michaelis method can successfully be used also as an approximate analytical method of determination of the breakthrough curve, though it may perhaps be better for recalculating the results of model investigations where higher accuracy should be expected.

In conformity with the Michaelis concept the breakthrough curve is defined in the new system by replacing the time coordinate by a coordinate which represents the volume of the inert gas that leaves the bed (Fig. 3), according to the relation

$$W_A = \tau G_s$$

where

W_A — the quantity of the inert gas which passed through the bed, kg/m²,

τ — time, hours,

G_s — the inert gas rate, kg/m²·hr.

The breakthrough curve is plotted as $Y = f(W)$ where Y is the unit concentration expressed in kilograms of the adsorbate per one kilogram of the inert gas. In Fig. 3 are additionally marked the concentrations at the breakthrough point Y_B and the saturation concentration Y_E calculated. Both these quantities are assumed symmetrically with respect to a half of the inlet gas concentration Y_o like, for instance, $Y_B = 0.1\ Y_o$ for the breakthrough point (at a time τ_B), $Y_E = 0.9\ Y_o$ at the point that corresponds more or less to a bed saturation condition (at a time τ_E). The adsorption zone height is given by the relations

$$h_a = h\,\frac{\tau_E - \tau_B}{\tau_B + f(\tau_E - \tau_B)}$$

where

$$f = \int_{\tau_B}^{\tau_E} \frac{(Y_o - Y)\,d\tau}{Y_o(\tau_E - \tau_B)}$$

or

$$f = \frac{F}{Y_o W_a} = \frac{\int_{W_B}^{W_E} (Y_o - Y)\,dW}{Y_o W_a}$$

where

h — the absorbent bed height, m,

h_a — the adsorption zone height, m,

and the other symbols are in Fig. 3.

The adsorption zone thus determined depends on the temperature of the process and on the initial adsorbate concentration Y_o but it is independent of the bed height. Known the mass transfer conditions and the way the equilibrium line runs the dependence of h_a on temperature and Y_o may be determined. The degree of saturation of the adsorbent bed at the moment of the breakthrough will thus be expressed by the relation

$$\Phi = \frac{h - f h_a}{h}$$

This value is of significance in balancing of the adsorption process especially when the adsorption zone height is of the same order as the adsorbent bed height. The degree of saturation can, therefore, be determined provided that the h_a and f values are known which are roughly constant at a constant temperature and for a specified Y_o concentration.

An instance of the application of the constant adsorption zone concept may be the adsorption of benzene from moisture-laden gaseous effluents [23].

Comparison of the adsorption process from a dry and a humid gas examined in that study is illustrated in Fig. 4. Results obtained in that study demonstrated that the water vapor content in gas has practically no effect (within a certain range of the process variables) on the adsorption zone height (Fig. 5).

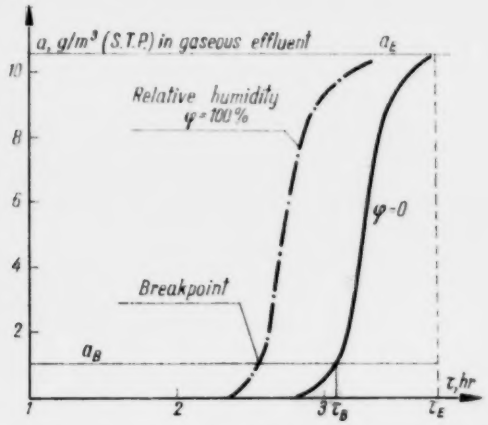

Fig. 4. A breakthrough curve for a dry and a moisture-saturated gas.

Thus the method described can successfully be used in calculating the adsorption process of benzene vapors from a humid gaseous effluent on the basis of the adsorption zone height values determined for the dry gas, and

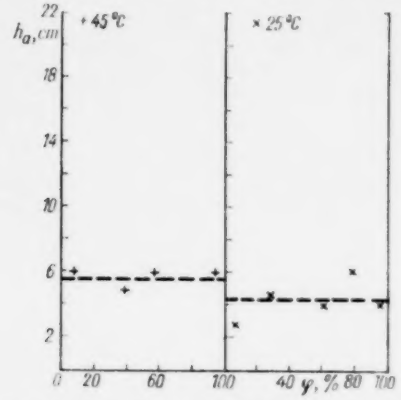

Fig. 5. Relation of the adsorption zone height vs. gas relative humidity.

with the aid of the data on the sorptive properties of activated carbon toward benzene in the presence of water vapor [23].

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THE SO_2 CONVERSION IN THE ATMOSPHERE AS A BASIS FOR THE ENVIRONMENT POLLUTION FORECASTING

(Konwersja SO_2 w atmosferze jako podstawa prognozy zanieczyszczenia środowiska)

A new concept of the environmental pollution forecasting is advanced which results from the significance of the SO_2 conversion in the atmosphere. The SO_4^{2-} anion concentration is suggested as an indicator of both the atmosphere emergency condition and a large-scale environmental pollution due to the SO_2 emission. The need for a treatment of the environment pollution on an integrated basis is substantiated.

Sulfur dioxide as a compound of a rather high chemical reactivity undergoes chemical reactions in the atmosphere. The best known are reactions of a catalytic type in liquid phase in the presence of such metals as iron, manganese, or others as catalysts, and reactions in gaseous phase induced by ultraviolet radiation [4], [6]. The following reaction occurs in the liquid phase

$$2SO_2 + 2H_2O + O_2 \xrightarrow{\text{catalyst}} 2H_2SO_4 \qquad (1)$$

The mechanism of the above reaction is obscure. According to some American investigations the reaction is of a chain type and is initiated by the addition of sulfite ion with a metal salt solution [2]

$$MnSO_4 + SO_3^{2-} \rightarrow I \qquad (1a)$$

where

I — is an unidentified intermediate. The photochemical reactions have the form [4]

$$\begin{aligned} SO_2 + h\nu &\rightarrow \dot{S}O_2 \\ \dot{S}O_2 + O_2 &\rightarrow SO_4 \\ SO_4 + O_2 &\rightarrow SO_3 + O_3 \\ SO_3 + H_2O &\rightarrow H_2SO_4 \end{aligned} \qquad (2)$$

Some authors admit a possible reaction pattern which involves atomic oxygen [8]

$$\begin{aligned} NO_2 + h\nu &\rightarrow NO + O \\ SO_2 + O &\rightarrow SO_3 \end{aligned} \tag{3}$$

This pattern is confirmed by a high quantum yield of the NO_2 photochemical reaction compared with the analogous SO_2 reaction.

More recent studies point to some other processes as essential in the SO_2 removal from the atmosphere, notably reactions of SO_2 with radicals such as alkyls, alkoxyls, and peroxyalkoxyls [1]

$$\begin{aligned} R(RO,RO_2) + SO_2 &\rightarrow RSO_2(ROSO_2,RO_2SO_2) \\ RO_2 + SO_2 &\rightarrow RO + SO_3 \end{aligned} \tag{4}$$

The reactions of SO_2 are responsible on one hand for the removal of SO_2 from the atmosphere and, on the other hand, these may result in a rapid increase in the atmosphere emergency situation under weather conditions of stagnant air and fog [16].

Investigations on the SO_2 conversion are conducted along the following two lines: the model studies in chemical reactors, and investigations under real conditions in the atmosphere. The SO_2 conversion in the atmosphere can be determined by an indirect method by comparing SO_2 concentration with concentration of the chemically inert compounds or, by direct measurements, of the SO_2 reaction products formed in the atsmosphere.

The investigations carried out to date in Cracow have been based on a comparative analysis of concentrations of SO_2 and Fe^{3+} where the ferric cation served as an inert component. Results of these investigations demonstrated the critical effect of the SO_2 conversion process under weather conditions associated with prolonged inversions and heavy fogs. In such periods a substantial rise in the Fe^{3+} concentrations observed was not paralled by a proportional growth in the SO_2 concentration [9]. This fact may be explained in terms of a catalytic oxidation of SO_2 (1) under specified conditions and, thereby, points to the need of direct determinations of the SO_2 conversion products in the atmosphere.

The Method of Investigations

In the forecasting the air pollution condition the SO_2 concentration plays a part of a forecast variable and the studies in this field are focussed on a suitable selection of predictors [15], [17].

$$X = f(x_1, x_2, x_3 \ldots x_k) \tag{5}$$

where

X — the SO_2 concentration,

$x_1, x_2, x_3 \ldots x_k$ — the predictors.

Nevertheless, in view of a considerable, occasionally even drastic, increase in the air pollution level due to the SO_2 emission, the left-hand side of relation (5) deserves some attention — that is, a suitable forecast variable must be chosen. The sulfate ion that is generated in the atmosphere is suggested as an indicator of the emergency condition which results from the SO_2 emission into the atmospheric air. The air pollution condition, therefore, will be determined by the relation

$$W_1 = [SO_2] + [SO_4^{2-}] \tag{6}$$

where

W_1 — the atmosphere emergency indicator on a local scale.

It is also essential to know whether the sulfate ion is bonded to hydrogen or to other cations. To establish atmospheric conditions under which the SO_2 reactions in the atmosphere, as well as the reactions of other contaminants occur is the main objective of the chemistry of the atmosphere with the aim to determine the function which refers to chemical transformations of the pollutants in the atmosphere

$$\frac{\partial S}{\partial t} = kS \tag{7}$$

where

t — time,

k — a constant.

On the grounds of the consideration of the nature of the processes related to the pollutants dispersion in the atmosphere, on an integrated basis, Kasina [10] formulated a relation in terms of which the pollutant concentrations in the air can be expressed in a general form as a function of the following parameters

$$S = f(E, P, M, C, t) \tag{8}$$

where

E — a factor characteristic of the emission parameters,

P — a factor that determines the coordinates of the measuring point relative to the emission sources examined,

M — a factor characteristic of meteorological parameters,

C — a factor responsible for the chemical and physical transformations of the pollutants in the atmosphere,

t — time.

In the aspect of the reactions of the pollutants in the atmosphere interpretation of the parameters mentioned above is as follows:

— atmosphere, more exactly in this case its lower layer, plays the part of a reaction system,

— the emission levels of the compounds present in the atmosphere equal concentrations of the substrates,

— removal of the reaction products or the substrates from the reaction system occurs via such processes as sedimentation, washout, rainout, and other scavenging mechanisms, direct absorption of pollutants by water surface on the ground, by soil and vegetation,

— inversion and calm in the atmosphere result in an increased reaction time of the pollutants,

— heavy fogs and the presence of fine airborne particulates are associated with an increased interface area which affects the reaction rate.

The investigations were conducted in the Environmental Science Institute in Cracow. Sulfur dioxide is determined independently by the West-Gaeke method and the hydrogen peroxide techniques to which the following reactions refer

$$2Na^+ + (HgCl_4)^{2-} + 2SO_2 + 2H_2O \rightarrow 2Na^+ + Hg(SO_3)^{2-} + 4H^+ + 4Cl^- \quad (9)$$

$$SO_2 + H_2O_2 \rightarrow H_2SO_4 \quad (10)$$

Reaction (9) is specific for sulfur dioxide. When SO_2 is determined using reaction (10) it should be remembered that in the absence of other sorbents both the SO_4^{2-} anions produced from the SO_2 oxidation by H_2O_2 and the SO_4^{2-} anions generated in the atmosphere are determined — that is

$$(SO_4^{2-})_{total} = (SO_4^{2-})_a + SO_4^{2-} \quad (11)$$

where

$(SO_4^{2-})_{total}$ — the total sulfate ion concentration,

$(SO_4^{2-})_a$ — the sulfate anion concentration for the hydrogen peroxide reaction of SO_2 in the measuring apparatus,

SO_4^{2-} — the sulfate anion concentration for the SO_2 oxidation process in the atmosphere.

In this case the SO_2 conversion in the atmosphere is, therefore, of a latent nature.

In fog, atmospheric precipitations, fallout, and in the airborne and deposited particulates the sulfate aerosol is determined by a spectrophotometric titration using barium perchlorate in alcoholic solution against thorin as indicator [3], [5]. The determination is based on the reaction

$$\begin{aligned} Ba^{2+} + SO_4^{2-} &\cdot\cdot BaSO_4 \\ 2T + Ba^{2+} &\cdot\cdot T_2^1Ba \end{aligned} \quad (12)$$

where

T — thorin — that is, trisodium salt of 1-(*o*-arsonophenylazo)-2-naphthol-3,6-disulfonic acid,

T_2^1Ba — the sodium-barium salt of the above acid.

The measurements are carried out in a continuous manner relative to a 24-hr period at a station situated in Cracow-Wola Justowska.

Measurements of the SO_4^{2-} content in atmospheric precipitations should be introduced to the determinations on a nationwide basis. This should be considered as an urgent necessity in view of the following considerations. Under national conditions the coal combustion processes are still a major air pollution source. The developement of the power industry, which every year becomes increasingly violent, is still based on brown coal and bituminous coal fuels. The use of coal in power industry is justified on economic grounds. The problem of desulfurization of fuels and exhaust gases is open yet on a global scale [13]. One of the means one has to resort to under these circumstances is construction of high stacks.

From the foregoing conclusions a fundamental question arises to what an extent the line of developement of power industry in this country poses a threat to the natural environment. Construction of high-stack power and heating plants is accompanied by limitation of individual heating systems and elimination of small boilerhouses of low stacks. Air pollution by SO_2 emissions from the latter two heating systems in the surface layer of the atmosphere is remarkable [12], [16]. Increased use of coal-based electric power in transportation and in other fields automatically restricts emission of highly toxic compounds present in the vehicle exhausts, from railroad locomotives, and others. Thus the immediate advantages that result from construction of high stack are unquestionable. The SO_2 measurements conducted in this country show generally no constant increase in the SO_2 concentration in the surface atmosphere layer in particular years. Analysis of the air pollution should be made, however, on an integrated basis, in virtue of relation (6). For the SO_2 emission from high stacks a very deep conversion of SO_2 must be remembered as the process that proceeds longer in the atmosphere. In the processes of condensation of water vapor during formation of clouds sulfur dioxide turns into the SO_4^{2-} form and its further dispersal is connected with migration of clouds. Scavenging of the sulfur compounds by precipitations appears to be critical in the SO_2 removal processes from the atmosphere on a global scale [7].

Thus the SO_4^{2-} content in precipitations is suggested here as an indicator of the environment pollution due to the SO_2 emission into the atmosphere

$$W_2 = [SO_4^{2-}] \text{ in precipitations} \tag{13}$$

The cleaning of the atmosphere by precipitations is accompanied here by pollution of soil and hydrosphere.

The above considerations clearly demonstrate that the environment protection should be treated on an inte .ed basis, including the atmos-

phere, soil, and hydrosphere, the point that has already been advanced in Poland by Parczewski [14].

For the measurements of the SO_4^{2-} concentration in precipitations a suggestion is made to set up a network of about 18 measuring points over the whole area of this country: Northern Poland 3 points, Central Poland 3 points, Southern Poland 8 points, and the Mountains Region 4 points. Determination of the time-space distribution of the SO_4^{2-} concentration in precipitations and its integrated interpretation (8) should form a basis for the estimation of the effect of the SO_2 emissions due to coal combustion on the large-scale environment pollution. This quantity should also be an indicator of emergency conditions for excessive threshold limit values of SO_2 emissions in the atmosphere which would require a limitation of these emissions.

Conclusions

1. In particular industrial regions research should be launched on the SO_2 conversion in the atmospheric air.

2. The sulfate ion that is generated in the atmosphere is suggested as an indicator of the emergency condition arising from SO_2 emission.

3. The sulfate ion concentration in precipitations should be assumed as an indicator of a large-scale environment pollution due to the SO_2 emission into the atmosphere.

4. Environment protection problems should be treated on an integrated basis including atmosphere, hydrosphere, and soil.

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THE ELECTRIC CAR AND THE PROBLEM OF ENVIRONMENT PROTECTION

(Samochód elektryczny a problem ochrony środowiska)

On the basis of the data from the United States it is claimed that the emission figures are favorable for the electric car compared with the car driven by internal combustion engine.

The problem of motor vehicle emissions produced in great quantities becomes of critical significance for a large number of countries in the world. Substantial money is poured into the research concerned with both the engine design and the fuel mixture composition to reduce toxicity of the exhaust gases. The research projects gain in intensity, as the number of motor vehicles moving on roads increases.

The ever-growing number of cars makes the problem of clean air to become of prime importance particularly for congested urban areas. A single motor vehicle may be regarded as a point emission source.

A feature of the internal combustion engines is that there are only limited preventive means available for the exhaust emissions treatment, because such engines operate under variable combustion conditions that are different for the starting period, nominal load, idle run, or full load conditions. Even if an efficient antipollution system is developed, this will undoubtedly increase the fuel consumption and the car price. Hence the attempt to replace the energy source for motor vehicles is quite understandable.

Today the most promising appears to be the electric energy as a new energy source for motor vehicles. Electric energy can be obtained from a large number of energy cells and thus it can successfully be used for driving motor vehicles.

Air Pollution Due to the Motor Vehicle Emissions

The official forecasts as to the number of passenger cars in Poland in 1990 provide two variants, notably: either 1–6 million cars or 2–4 million cars. The milage (kilometrage) per year for a passenger car in this country ranges from 10 to 15 thousand kilometers (on the average 12.5 thousand kilometers). In view of a substantial share of the electric delivery cars and taxi cabs a factor of 1.4 was assumed which affords an estimated 17.5 thousand kilometers per year for these car types.

The same official sources suggest two variants for the forecast number of the electric cars in 1990:

(1) a 20 percent of the total of passenger cars will be electrically powered which gives, according to the forecast variant given above (the maximum figures are taken):

(a) 1.2 million cars, or

(b) 0.8 million cars,

(2) a 50 percent of the total of passenger cars will be electrically powered which gives, according to the forecast variant assumed:

(a) 3 million cars, or

(b) 2 million cars.

The quantities of individual emissions which would be released by the same number of conventional motor wehicles are collected in Table 1. The following emission figures were assumed (after [1]): 0.26 g/km hydrocarbons, 2.1 g/km carbon monoxide, 0.25 g/km nitrogen oxides, 0.09 g/km

Table 1

Air Pollution with Motor Vehicle Exhausts

Variant	Number of motor vehicles millions	Emission of:			
		hydrocarbons thou tons	CO thou tons	NO_2 thou tons	SO_2 thou tons
1 (a)	1.2	5.5	44.1	5.3	1.9
1 (b)	0.8	3.6	29.4	3.5	1.3
2 (a)	3.0	13.7	110.3	13.1	4.7
2 (b)	2.0	9.1	73.5	8.8	3.2

sulfur oxides. The sulfur content in the fuel was taken as 0.033 percent of the fuel weight, and the fuel consumption for cars was assumed as 10 l/100 km on the average. The sulfur oxides emission for gasoline engines consists of the sulfur oxides coming out directly from the engine and from those produced in the petroleum refining process.

The Electric Car and a Changed Structure in the Electric Power Generation

It is essential to realize how the future rise in demand for electric power for electric cars will affect the air pollution due to power industry (power plants).

Admittedly, the average power requirement of an electric car will be about 0.4 kWh/km. For an average yearly milage of about 12.5 thousand kilometers estimated this provides a power requirement for one electric car of an order of 5000 kWh/year. For the number of 4 million cars forecast this corresponds to a power requirement of an order of 20 TWh. This quantity can be generated in a single power plant unit of a 2500 MW capacity for 8000 hr yearly. Obviously, a power-generating unit of such a spatial concentration will be far less harmful to the environment than many millions of gasoline cars that are much more difficult to control. Likewise, an

Table 2

The Predicted Improvement in the Power-Plant Emission Figures in the United States, kg/100 kWh

Year	Percentage of the total of the nuclear-plant power	Coal-fired plants			Mixed-type plants		
		SO_2	NO_2	solids	SO_2	NO_2	solids
1980	30	0.36	0.23	0.05	0.25	0.16	0.032
1990	50	0.18	0.14	0.02	0.09	0.07	0.011
2000	70	0.18	0.14	0.02	0.03	0.04	0.007

increased share of electric power produced in nuclear power plants relative to the total power generated substantially affects the quantity of emission of pollutants from the power plant stacks. The forecast improvement on the emission figures for power plants until the year 2000 after the data on the development of the US power industry is illustrated in Table 2.

Comparison of the Emissions from Motor Vehicles of Both Types

Comparison of the emissions from gasoline and electric motor vehicles after the analyses by J. T. Salihi [1] for USA is given below.

Hydrocarbon and carbon monoxide emissions

On the assumption that the total expected increase in number of motor vehicles refers exclusively to the gasoline engine cars, an estimated double emission level is predicted by the year 2000. Obviously, the electric car will

substantially reduce that level. Presented in Fig. 1 is a graph for the carbon monoxide emission level for the variant providing the increase in the conventional engine cars (curve *a*) and for the variant that refers to both the conventional engine and electric cars (curve *b*). The curves also represent the hydrocarbon emission level.

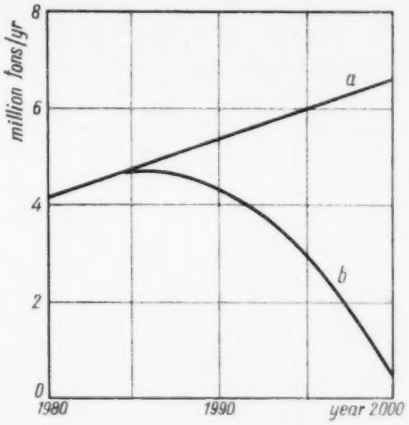

Fig. 1. Decrease in the carbon monoxide emission: *a* — gasoline cars, *b* — gasoline and electric cars.

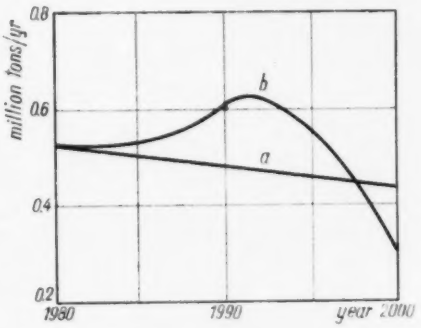

Fig. 2. Decrease in the nitrogen oxides and sulfur oxides emissions: *a* — gasoline cars, *b* — gasoline and electric cars.

Sulfur oxides and nitrogen oxides emissions

A graph for the emission level of sulfur oxides and nitrogen oxides for the analogous variants as in the preceding paragraph is illustrated in Fig. 2. Curve *b* which refers to the emission level for a joint increase in number of both gasoline cars and electric cars is only slightly higher than curve *a*. For subsequent years the lowering of curve *b* below curve *a* would be possible owing to an increasingly large share of electric cars in the total of motor vehicles. As a factor for gasoline cars sulfur oxides emission level of 0.09 g/km was taken at an average fuel consumption of about 10 l/100 km and a fuel sulfur content of 0.033 percent of the fuel weight.

Solid particulate emissions

The forecast estimates as to the share of electric cars in the total number of motor vehicles provide grounds for the believe that the emission level of solid particulates will be substantially diminished (Fig. 3).

The data in Figs. 1–3 clearly indicates that increased use of electric

cars results in lowered air pollution. Actually, the air pollution associated with the use of electric cars will be far lower than shown in Figs. 1–3. It should be borne in mind that the emission will be released from few point sources (the power-generating units). Theoretical considerations indicate that pollution of the environment by a multitude of gasoline engines is from 5 to 10 times higher than the emission level from point sources such as power plants located at a large distance from great urban areas which additionally release the emissions through high stacks.

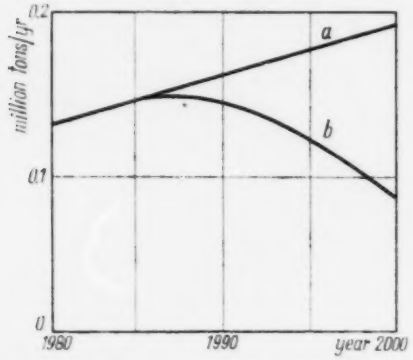

Fig. 3. Decrease in the solid particulate emission: *a* — gasoline cars, *b* — gasoline and electric cars.

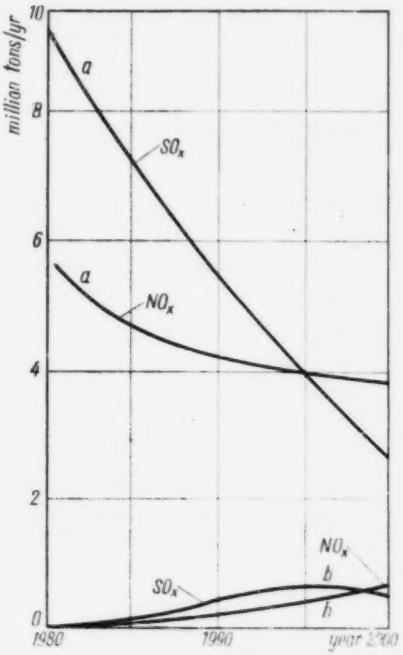

Fig. 4. Rise in the air pollution due to the power plant emissions: *a* — total emissions, *b* — the pollution due to a higher requirement for power by electric cars.

Increased Pollution Level Due to a Higher Power Requirements

The electric car will bring about increased power plant emission level to meet the extra requirement for electricity needed to charge the car batteries. This increase in pollution will be commensurate with the increased power requirement. This extra requirement for electric power needed for electric cars, however, will be insignificant compared with the overall power. Hence, the rise in the environment pollution due to the power plants on account of an increased popularity of the electric car will be minor.

The increased sulfur oxides and nitrogen oxides emission level due to the spreading use of the electric car against that level resulting from an

overall power requirement is illustrated in Fig. 4. The graphs were set up on the basis of the expected structure of the power industry provided in Table 2.

Conclusions

The environment pollution figures reported on the basis of research and analyses made in the United States [1] and in the Federal Republic of Germany [2] are in favor of the electric car. This holds true even if an expected rise in the power requirement with its parallel increase in the emission volume is considered.

The estimates and figures reported in this review are of an approximate nature, as a large number of rough values as to the development of transportation and power production had to be assumed. The above considerations are a contribution to the answer to the question, whether the electric car will cause increased emission level?

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DETERMINATION OF AIR POLLUTANTS BY THE RING-OVEN TECHNIQUE

(Oznaczanie zanieczyszczeń powietrza metodą pieca pierścieniowego)

The ring-oven technique is described in its use for the determination of air pollutants. Analytical procedure is given for copper, beryllium, mercury, iron and lead determinion in the air.

The ring-oven technique, known also as ring or comparative colorimetry, represents a modification of the spot analysis on the filter paper [9]–[12]. For a correct analysis to be made, a drop of the solution containing the unknown applied to the filter paper must be spread to form a concentric, continuous line in which the entire amount of the unknown is contained. The technique is suitable for detection, separation, identification, and quantitative determination of both organic and inorganic compounds. Attractiveness of this technique is due to the fact that the apparatus can be easily made even on one's own, analytical procedure is simple and requires a relatively short time, as well as that the technique is reproducible and provides a satisfactory accuracy.

The above qualities of the ring-oven technique called understandable attention [13], [14] to its use in determination of air pollutants.

The Ring Oven

The classical Weisz ring oven incorporates three metal rings (Fig. 1). The bottom ring *1* is provided with legs and serves as a base. The middle ring *2* represents the proper oven whose dimensions are: outside diameter — 55 mm, inside diameter — 22 mm, and height — 35 mm. An electric heater is provided inside of that ring. The top ring *3* is used to hold down a paper disk on which the determination is carried out. A clamp is attached to the bottom ring to hold a glass tube *4* that is positioned exactly above

the center of the 22-mm opening in the oven ring. This tube constitutes a guide for a micropipet to apply the solutions under analysis and the developing solvent onto the paper.

The oven is supplied from the lines through a Variac to control the temperature measured by a suitable thermometer 5 provided.

The materials used for construction of the oven include a variety of metals such as aluminum, copper, or steel, and the outside of the heating block was electroplated with such coatings as gold, platinum, silver, or chromium.

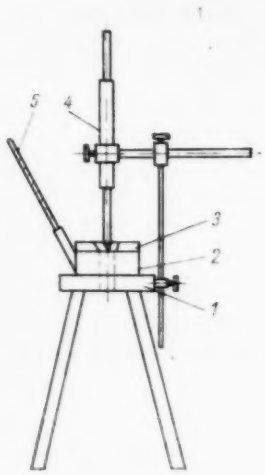

Fig. 1. Diagrammatic sketch of the ring oven: *1* — bottom ring, *2* — middle ring, *3* — top ring, *4* — glass guide, *5* — thermometer.

Analytical Procedure

Philosophy of the analysis using the ring oven may be regarded as that of the spot colorimetry. Concentration of the unknown in a solution under analysis is determined by comparison of the intensity of the rings obtained on the paper for the unknown with that of the reference rings prepared for a standard solution of a known concentration.

The reference scale is set up by applying successively a varing number of drops of a standard solution of a known concentration, followed by development of individual spots with a suitable solvent. The analysis of the unknown is made by applying with a micropipet successively 1, 2, 4, 6, 8, and 10 drops of the solution under test onto the very center of paper disks accommodated in the ring oven, followed by development of the unknown present in the spot with a suitable solvent. Upon treatment with a suitable reagent six ring-shaped spots are made visible. All these rings obtained on the paper disks are of the same shape and diameter independent of the amount of the unknown, although they differ by their intensity. By comparing the intensity of the ring of the compound under analysis with the corresponding reference rings the concentration of the solution analyzed can be estimated. During the application of the solution under analysis onto the paper and the development of the spots, the heating block of the oven should have a temperature by 10°C higher than the boiling point of the solvent used.

The air sampling technique for the analysis of the air pollutants by

the ring-oven technique is analogous with that for other methods. The exact air sampling procedure depends on the chemical and physical nature of the pollutant to be determined.

Accordingly, gases and vapors are usually taken up in suitable washing bottles filled with an absorbing liquid, and the liquid is subsequently applied with a micropipet onto the paper disks.

On the other hand, for the analysis of aerosols (fumes, particulate emissions) generally filter paper is employed. The sampling procedure consists in passing a known volume of the air under analysis through a paper disk held in a suitable holder so as to make the aerosol collected as a spot about 6 mm in diameter at the center of the disk. The paper disk in turn is placed in the ring oven and the uknown is developed with a suitable solvent.

Determination of Inorganic Compounds in the Air

The ring-oven technique has primarily found an application for determinations of metallic elements in the air. Given below is a review of the most interesting work in this field.

Copper

West and Weisz [19] and West and Pitombo [18] determine copper in the air using a Whatman 41 filter paper, and dioxamide in ethanol as the detecting reagent. With this reagent 0.015 μg of copper can be detected, whereas a quantitative determination can be made for 0.1 to 0.5 μg Cu. The interfering effect of foreign ions is completely eliminated when a 5 percent solution of malonic acid is used as a masking reagent.

Beryllium

Determination of beryllium in the air was the subject of two studies. West and Mohilner [17] adopted a spectrophotometric method based on a reaction with eriochrome R cyanine at pH 9.8. The samples containing beryllium withdrawn from the air are dissolved in hydrochloric acid. Whatman 41 paper is the best grade for the determination. The procedure is suitable for determination of 0.05 μg beryllium with an accuracy of 7 percent. Interfering in the analysis are Mg, Al, Th, Cr when in a 100-fold excess.

West and Jungreis [16] worked out a procedure for determination of beryllium using morin and a 0.1M EDTA solution as a masking reagent. The procedure for identification and quantitative determination of beryllium involves the use of fluorescence (irradiation with a UV lamp) of the product of the reaction of Be^{2+} ions with morin.

Mercury

A strongly toxic activity of mercury and its widespread use in a variety of manufacturing processes urge a search for new more accurate analytical procedures for determination of vapors of this element in the air. One of these procedures is the method developed by West et al. [8] by the ring-oven technique. The method is suitable for determination of microgram quantities of mercury (0.5 μg) without a prior separation of the accompanying elements. The authors recommend a Whatman 2 paper for that analysis. Upon application of the reference standards and the unknown onto the paper disks, the rings are to be developed using successively, 10 μl 0.05N HCl, 10 μl 1 percent aqueous hydroxylamine hydrochloride solution, and again two of 10-μl portions of 0.05N HCl solutin.

When dry, the disks are treated with ammonia vapors to make the rings visible. The determination of mercury vapors by this procedure is affected by the presence of Ag^+ ions, if more than 10 μg in the sample, and also $[Fe(CN)_6]^{3-}$, $[Fe(CN)_6]^{4-}$, Au (III) and Pd (II). In view of a scarcity of these materials in the air pollutants their interfering effect can be ignored.

Iron

In the author's laboratory a new, as yet unpublished, technique was evolved for the determination of iron in the welding fumes. In that method the iron pollutant present in the welding fumes was collected directly on the paper disks which were subsequently used for analysis in the ring oven. Whatman 41 paper disks, 29 mm in diameter, were placed in a metal holder and shielded with a foil membrane in the very center of which an opening of a diameter of 6 mm was provided. The holder along with the disk was connected threadedly to a hand-operated suction pump of a volume of 100 cm^3 designed to sample a suitable volume of air for the analysis. A sufficient air volume for the analysis was 100–300 cm^3. The disks with the samples collected were removed from the holders, placed on watch glasses, and the precipitate was dissolved by applying one drop of a 1N HCl solution from a capillary pipet so that the acid spot should not be larger than 6 mm. The operation was repeated, and then the filter paper was inserted into the ring oven heated to 125°C, and the spots were developed with a 0.01N HCl. Distinct rings, 22 mm in diameter, obtained were treated with potassium ferrocyanide to make them visible. The color rings obtained for the unknown samples were compared with a reference scale composed of six rings which contained iron (in terms of Fe_2O_3) respectively: 0.0002, 0.0004, 0.0006, 0.0008, 0,0012, and 0.0024 mg Fe_2O_3.

The quantity of Fe_2O_3, in mg, per one cubic meter of air was calculated from the formula

$$X = a10^6/V$$

where

X — the Fe_2O_3 content, mg/m³ air,

a — the Fe_2O_3 content, mg, in the reference ring, corresponding to the ring under analysis,

V — the air volume sampled for the analysis, cm³.

The above procedure was used in the determination of Fe_2O_3 in the welding fumes in an assembly room where about 40 welders work. A total of 70 determinations was carried out at the stands of the manual coated-electrode arc welding. The iron content in about 75 percent of the results ranged between 1.0 to 8.0 mg Fe_2O_3/m³ air being, therefore, lower than the standards in force. In the remaining 25 percent cases the Fe_2O_3 content considerably exceeded the admissible standards, and the instantaneous concentration occasionally reached as high as 120 mg Fe_2O_3/m³ air.

The described method of determination of Fe_2O_3 in the welding fumes by the ring-oven technique is featured by the following advantages:

— short time required for the analysis which for five samples is not longer than 30 min,

— low cost and simplicity of the apparatus required,

— extremely convenient sampling procedure,

— minimum reagent consumption,

— adequate sensitivity for the purpose, which is 0.2 μg Fe_2O_3,

— that is, for an air sample of 200 cm³ withdrawn 1 mg Fe_2O_3 can be determined in 1 m³ air.

Lead

Determination of lead was the subject of a number of papers [1], [2], [4], [6], [19]. West et al. [19] recommend the use of sodium rhodizonate reagent to detect the Pb^{2+} rings, which permits a detection of lead in a quantity of 0.015 μg.

The procedure developed by Jungreis and West is suitable for an accurate determination of lead in a range of 0.05 to 2.0 μg. As the indicator reagent diphenylcarbazide in acetone and fumes of hydrochloric acid are employed. Not interfering in the analysis are 10-μg quantities of arsenic, aluminum, beryllium, cadmium, calcium, cobalt, manganese, mercury, magnesium, palladium, silver, titanium, and zinc.

A method has been worked out in the author's laboratory for the determination of tetraethyl lead in air. The determination was performed

in an auto service station. The air to be analyzed was made to pass through glass wool filled washers in which the wool was moistened with concentrated nitric acid. The tetraethyl lead vapors were absorbed in the washers and, subsequently, the Pb^{2+} produced was washed out from the wool with concentrated HNO_3. Upon evaporation of the acid the residue was dissolved in cold water of a known volume. The determination was made on Whatman 1 paper disks at an oven temperature of 160°C and using a 1 percent HNO_3 as the developing reagent. The Pb^{2+} rings obtained were made visible with a thioacetamide reagent. A quantity of 0.3 μg Pb^{2+} can thus be determined in the sample. The concentration of tetraethyl lead in the air of the service station tested in terms of Pb^{2+} amounted to 0.02, 0.005, and 0.004 mg/1 m^3 air during three consecutive days.

Other authors [1], [2], [4] set forth the chromate reaction for making the rings visible. Lead in quantities of up to 0.5 μg can thus be determined. No effect of interfering ions is observed, and a good agreement of the results is achieved with the results of the analyses performed using the atomic absorption spectrophotometry technique [2]. In addition to the metals described other elements were determined in the air, such as selenium [15], chromium, manganese, cobalt and nickel, zinc and cadmium [19].

The ring-oven technique was also used for the analyses of organic compounds. In the case of air analysis of particular relevance are the procedures reported for determination of caffein [5] and nicotine [7].

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Madany, A.

A COMPLEX ATMOSPHERE SELF-PURIFICATION INDEX

(Kompleksowy wskaźnik samooczyszczania się atmosfery)

A tentative characteristic of the ventilation conditions of the atmosphere is given for the Warsaw area on the basis of radiosonde measurements data. Analysis of the data shows on the average satisfactory ventilation conditions in that area.

The pollution level in the atmosphere may substantially differ in various regions depending on their climatic and orographic peculiarities, even for the same emission volume of the pollutants of interest. Variations in the pollutant concentrations with time are conditioned by the complex of weather conditions. Essential factors in the transport and dispersion of pollutants in the atmosphere are wind and the vertical thermal equilibrium. Until recently in Poland usually only anemometric relations were reported to estimate the average for a given area meteorological conditions for the air pollution control purposes. Originally a common practice was to consider the surface wind rose. Later other characteristics have come to be used up to the recently introduced wind dispersion coefficient [6]. Apart from that meteorological parameter some of the studies provide characteristics of the vertical thermal equilibrium tabulated in a variety of ways. In this connection it appears reasonable to introduce a quantity that would account for both the aforesaid elements, the quantity which is the ventilation index. Ventilation index has become an additional climatic characteristic [3] and is calculated today on a permanent basis in routine forecasting of the air pollution potential in the United States and other countries [1].

In 1964 Holzworth introduced the concept of mixing depth understood as a thickness of the surface air layer in which relatively intense mixing takes place [2]. In the nighttime, very often owing to radiation of coolled-off ground which occurs during clear sky, surface inversions are formed of a variable range in which the air mixing is virtually inhibited.

In the daytime, especially in a warm season, owing to the heat impaired by the solar energy the atmospheric stability turns into an instability condition. Then a layer is produced in which usually intense vertical motions help mixing. It was assumed, neglecting other effects, that the maximum mixing depth for a given 24-hr period depends on the maximum temperature of the surface air and on the thermal structure of lower atmosphere [2].

The afternoon mixing depth maximum for that 24-hr period is defined as the height of the point of intersection of the dry adiabat, which corresponds to the maximum air temperature with the stratification curve obtained from its immediately preceding radiosonde measurement. In Poland the radiosonde measurement is customarily taken at 12:00 GMT. On the assumption that dry air is involved, the mixing depth thus defined will approximately characterize the thermal range of convection currents in the afternoon hours. In the air containing water vapor a mass element migrating without heat exchange with the environment, undergoes adiabatic temperature changes above the condensation point. The simplifying assumption of dry air made for the characterization of the most favorable, during the 24-hr period, vertical ventilation conditions is more convenient from a practical viewpoint.

Ventilation index is defined as a product of the mixing layer depth and the average wind speed within that layer. Thus it represents a measure of the volume of the horizontal transport of the mixed air per a unit length along the direction perpendicular to the wind direction. This complex index, therefore, characterizes self-purification of the atmosphere. For the forecasting purposes critical values of the parameters defined above were found experimentally. If those values are exceeded there is a situation of the maximum pollutant concentrations in the surface air layer.

Experimental Data

In this study ventilation index was used to characterize ventilation conditions in the Warsaw area. For that purpose the radiosonde measurements were considered which were taken in the years 1970–1971 in the afternoon hours at Legionowo by the State Hydrometeorological Institute Service. The Legionowo measuring point is situated out of town near Warsaw. However, the representativeness of that kind of measurements is assumed at a radius far exceeding the distance between the localities in question. Moreover, use was made in the calculations of the measurements of the maximum air temperature at a height of 2 m at Legionowo. It will be noted that the average air temperature in Warsaw is by about

1°C higher than the air temperature measured outside the city. This urban thermal island is generally marked during the nighttime and in the morning [4]. At noon and in the afternoon hours no difference was observed between the air temperature in Warsaw and its surrounding out-of-town areas.

A total of 711 radiosonde measurements data of 12:00 GMT hour were elaborated. For each datum were calculated the afternoon mixing depth, mean wind speed in the mixing layer, and ventilation index. The monthly and annual mean values of these quantities are tabulated.

Mixing Depth

The annual mean afternoon mixing depth in the Warsaw area equals about 1000 m. The monthly means of that quantity vary substantially over the year (Table 1, Fig. 1).

Table 1

The Monthly Mean Afternoon Mixing Depth Values during the Year

Month	The mixing depth value, m
January	264
February	542
March	669
April	1164
May	1383
June	1529
July	1626
August	1556
September	1149
October	770
November	556
December	381
Annual mean	973

The lowest value of the mixing depth occurs in January (264 m) whereas the highest value is noticed in July (1625 m) which is over six times the January estimate. In December and January the mean afternoon mixing depth is very low and not higher than 500 m. In the period of October through March it is lower than 1000 m, while in summer the value exceeds 1500 m. This picture agrees well with the frequency of

labile equilibrium of the air during the year [5], [7], as well as with a higher intensity of convection currents in summer. The values obtained in this study are very close to those obtained for the monthly mean afternoon mixing depths (from a five-year measuring series) by Holzworth [3] for the city of St. Clound, Minn. (northern part of the central States of the United States).

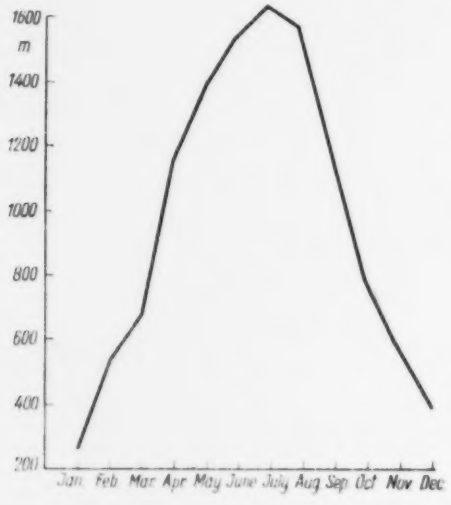

Fig. 1. The monthly mean afternoon mixing depth values for Warsaw.

Over the city of Warsaw itself larger mixing depth should be expected than presented in Table 1 since the town is aerodynamically rougher than nonurban area and has a greater heat capacity. Moreover, it follows from investigations of a number of authors that during inversion spells outside the town, often a well-mixed layer of a few hundred meters deep persists inside the town at an indifferent equilibrium.

Horizontal Transport

The mean wind speed, which is a measure of the horizontal speed of the mixed air layer, exhibits a minor variation during the year (Table 2). Assuming monthly average values ranging 6 to 9 m/sec, thus by 4 m/sec higher than the limiting speed below which, other conditions being also fulfilled, a potential air pollution can be predicted.

Taking into consideration, however, particular days it can be noticed

that the mean wind speed values in the mixing layer not exceeding 4 m/sec occurred in 20 percent of cases. The mean wind speed values in the mixing layer higher than 4 m/sec and lower than 10 m/sec occurred as often as in about 60 percent of cases. The mean wind speed values larger than 10 m/sec and not higher than 15 m/sec represented 16 percent, and those above 15 m/sec were observed in a mere 4 percent of cases.

Table 2

The Monthly Mean Wind Speed in the Mixing Layer during the Year

Month	The mean wind speed, m/sec
January	6
February	7
March	8
April	8
May	7
June	7
July	7
August	6
September	7
October	8
November	9
December	8
Annual mean	7

Mean Ventilation Conditions

At an average wind speed in the mixing layer not exceeding 4 m/sec a remarkable accumulation of pollutants takes place in the surface air layer if the ventilation index is lower than 6000 m²/sec [1]. In the Warsaw area both the annual mean ventilation index and the monthly means in the period of April through November are higher than the critical value (Table 3, Fig. 2).

The best ventilation conditions of the lower atmosphere are noted in July (10,802 m²/sec), and the worst ventilation conditions occur in January (2015 m²/sec). During the inhibited ventilation in winter observed municipal heating plants and residential furnaces are operative in that season so that emergency situations should be anticipated. It can generally be said, however, that the average conditions of ventilation of the atmosphere in the region of Warsaw can be regarded as satisfactory.

Table 3

The Monthly Mean Ventilation Index

Month	Ventilation index, m^3/sec
January	2015
February	3946
March	5352
April	10,700
May	8280
June	10,096
July	10,802
August	9917
September	8586
October	7506
November	6112
December	3968
Annual mean	7277

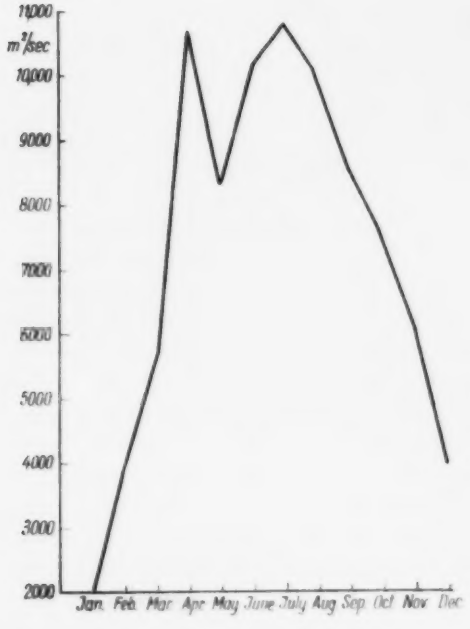

Fig. 2. The monthly mean ventilation index values for Warsaw.

The Inhibited Ventilation Periods

One-day episodes of inhibited ventilation are not dangerous. Only prolonged meteorological conditions that impair dispersion of pollutants bring about a strong accumulation of toxic compounds in the lowest atmospheric layer. Several-day periods of subcritical ventilation and weak winds in the mixing layer, coupled with no precipitation, usually lead to exceeded threshold limit values. The two-year period examined in this study is essentially too short for the frequency of such unfavorable periods to be established. Nevertheless, the tabulated data may serve as an illustration of this phenomenon. In the period 1970–1971 single 24-hr periods, with a ventilation index of < 6000 m³/sec and a wind speed in the mixing layer $\leqslant 4$ m/sec, were fifty-three, whereas the 48-hr periods of these parameters occurred twenty-three times. If the ventilation and the wind speed remain at a low level and there is no precipitation for three days or more, this condition is referred to as stagnation of the atmosphere [3]. During the 2 years examined 7 three-day periods and 4 five-day periods of a ventilation and a wind speed below critical were observed.

The five-day periods, the most dangerous, occurred in January, February, March, and October — that is, during the heating period. As many as four such periods occurred in 1971. The most adverse ventilation conditions, therefore, should be expected for the mere 6 percent days of the year.

Conclusions

On the basis of the radiosonde measurements carried out in the years 1970–1971 at Legionowo a tentative characteristic of the atmosphere ventilation conditions was given for the Warsaw area. The ventilation index and the afternoon mixing depth were found to vary clearly during the year with a maximum in July and a minimum in January.

The monthly mean wind speed in the mixing layer oscillates between 6 and 9 m/sec.

The monthly mean ventilation index values in the period of April through November are higher than the threshold value of 6000 m²/sec.

The annual mean afternoon mixing depth amounts to about 1000 m, and the annual mean ventilation index equals about 7300 m²/sec.

Adverse ventilation conditions occur during the mere 6 percent days of the year.

In general the average ventilation conditions in the Warsaw area can be regarded as satisfactory.

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LEGAL ASPECTS AND ORGANIZATION

THE FOREST BELT FOR THE UPPER-SILESIAN INDUSTRIAL REGION AND THE PROTECTION OF THE NATURAL ENVIRONMENT

It is unquestionably true that in heavily industrialized congested urban areas the menace to the environment and humans is the highest.

The adverse effects of industry and large industrialized urban areas on the ecosystem are evidenced by statistics of such social diseases as lung cancer, neuroses, or cardiovascular insufficiencies. In this connection there is a particularly large social demand for a variety of fundamental preventive measures to reduce the deleterious influence of industry on the natural environment. Under these conditions the significance of the decisions made by the authorities of the Katowice Voivodship as to the Forest Shelterbelt project for the Upper-Silesian Industrial Region becomes evident. The Forest Belt is devised to meet the following two main objectives: to save forests from destruction by reconstruction of stands from coniferous into mixed ones with a prevalence of deciduous stands, and to develop large forest areas for recreational purposes of the community. The idea, which triggered a vast public activity along these lines, has fully been shown to be right during as short a period of experience with the development of the project as six years. The results of the idea of the Forest Shelterbelt project encourage further activities in this field, an example of which may be the expansion of the Dolina Trzech Stawów recreational area to the largest municipal park in this country.

The question of the natural environment has become a pivotal issue in the socioeconomic complex of the phenomena of our civilization. Determination of its extent resolves itself invariantly into spatial delimitation to be able to demonstrate the problem in the dimensions of the area and of the number of population endangered by the adverse effect of man on its biosphere.

The most exposed area of this country, which incidentally has the highest population density figure 830 inhabitants per 1 km^2), is unquestionably the Upper-Silesian Industrial Region where an area of 2711 km^2 is inhabited by 2250 thousand people.*

*According to the 1974 figures also the areas of the following districts: Będzin, Gliwice, Tarnowskie Góry, and Tychy were included in the delimitation of the Upper-Silesian Industrial Region in addition to the Urban Complex A Upper-Silesian Industrial Region.

Systematic measurements of the air pollution level performed demonstrated that the dust precipitation was higher than admissible over the whole Upper-Silesian Industrial Region Area, and the concentrations of sulfur dioxide and nitrogen dioxide, in excess of the threshold limit values, were observed over most of the towns of the Upper-Silesian Industrial Region Complex (USIR Complex).

Under similar conditions urgent measures to prevent further aggravation of the atmospheric conditions became a necessity.

One of the many initiatives of the authorities of the Katowice Voivodship to improve the atmospheric conditions by limitations of toxic gaseous and other emissions released by industrial plants of Silesia and Zagłębie has been the resolution of the Polish United Workers' Party Voivodship Committee jointly with the Voivodship National Council Presidum on the development of the Forest Shelterbelt for the Upper-Silesian Industrial Region, accepted in the ultimate form of the resolution of the Economic Committee of the Council of Ministers No. 196/68 of June 27, 1968.

A basis for the concept of the USIR Forest Shelterbelt were the following two objectives:

— to save the forests situated on the USIR area from destruction due to the harmful influence of industry by replacement of coniferous stands for mixed ones with a prevalence of deciduous trees,

— development of the forested areas for health and recreational purposes of the population.

The lines of activity mentioned above have eventually merged into a vast stream of public activities and an activity project joined by the general public of the Katowice Voivodship. These lines of activity encompass a wide range of specialized work in the field of forest management and construction of recreational areas for rest and entertainment after the workdays to be used largely by the inhabitants of the nearby towns. The results achieved in the past six years in the development of this project have fully confirmed its need from the public interest standpoint.

Conservation of the forests and their protection against the adverse industrial activity is closely related to their biological regeneration. The biological regeneration of a number of forest complexes in the USIR is aimed at reconstruction of the biologically passive coniferous stands into biologically active stands. This is accomplished by the removal of conifers of inhibited growth and their replacement by deciduous varieties which are more resistant to gaseous and particulate emissions. The reconstruction of the forest stands has attained an importance of a leading problem in the general Forest Shelterbelt project. A link in this recultivation process is afforestation of industrial waste land and nonagricultural land.

A general reconstruction of the forest stands is accompanied by such projects from the field of the forest management as:

— decontamination of the affected forest soils,

— cultivation of crops and young stands,

— drainage of wet land,

— construction of new and repair work on old forest roads to make additional forest areas accessible.

The extensive program of forest management under the Forest Shelterbelt Project in question provided for the years until 1980 includes, among others:

— forest stand reconstruction over an area of 12,000 ha,

— land improvement projects over an area of 8850 ha,

— agricultural drainage projects over an area of 5860 ha,

— general management and restocking over an area of 2000 ha.

The results obtained under such a broad project is indicative of a high pace of the work performed. The remarkable dynamics of the work related to the observed agricultural drainage and land improvement operations, as

Table 1

The Forest Management Projects in the Development of the Upper-Silesian Industrial Region Forest Shelterbelt

Project kind	Unit	Planned till 1980
Nurseries	ha	90
Land improvement	ha	8850
Agricultural drainage	ha	5860
Construction and repair of forest roads	km	214
Construction of the administration and workers' settlements	no.	62
Corrections and restocking	ha	2000
Cultivation of crops and young stands	ha	18,620

well as the fast stand reconstruction project, make one to believe that the scope of the work scheduled until 1980 can be substantially expanded (Table 1).

The forest stand reconstruction will gradually alter the function of the forests incorporated in the Forest Shelterbelt development. In particular, as a result of the work planned, the function of forests as timber producers will yield to the function of forests in their health and recreation capacity reshaping them and changing their character toward that of the parks. The reconstruction of forest stands, coupled with reclamation of vast

industrial wasteland for the forestry purposes, will also contribute to an increased overall area of the forest land. Acquisition of industrial wasteland for the forest management purposes will require much recultivation efforts on an area of about 12,000 ha. This will be possible owing to new specialist executive organizations brought into existence, such as the Ministry of Forestry, Department for Recultivation and Afforestation.

Under the complex situation as to the environment protection over the USIR area the forests constitute the most essential factor in the improvement of the climatic and health conditions there, as well as in meeting the recreational needs of the population. In view of this fact it was assumed that on the basis of the local forests available, due to the above-mentioned projects, in a fairly short time an extensive recreational complex would be developed near the major inhabited localities. A typical Forest Shelterbelt recreational area should include according to the project design:

— a body of water adapted for swimming and water sports with beaches,
— generally accessible sports grounds for small games,
— children's playground area,
— entertainment facilities,
— grocery stores, bars, restaurants,
— toilets,
— promenades, alleys, and the areas for strolling and rest.

In this connection the localization directives for the development of recreational areas provide for the situation:

— peripheral relative to the forest complex for the nature conservation reasons and to create vast silent areas,
— in the vicinity of the mass transportation stops,
— close to the road network,
— in the neighborhood of the existing settlements for a joint use of the recreational areas,
— in conformity with the landscape requirements.

Besides, the localization concept of the Forest Shelterbelt provides for a highway loop to interconnect individual areas. This loop, a scenic highway of the parkway type having 250 km in length, will be an additional attraction for motoring users.

The development of and the facilities for the recreational area is preceded by detailed specifications worked out often in cooperation with such research centers as: the Silesian University Biology Institute (research on the Ecological Foundations for the Development of the Starganiec, Kochłowice, Gliwice-Zabrze Park Recreational Areas); the Polish Academy

of Sciences Industrial Region Environment Protection Department at Zabrze (research on the Climatic and Bioclimatic Conditions of the Forest Areas: Estimation of the Changed Morphology of the Upper-Silesian Industrial Region Areas; the Spatial Distribution of the Atmospheric Pollutants in the Upper-Silesian Industrial Region; the Health Condition of the Forests of the Upper-Silesian Industrial Region Forest Shelterbelt; Recreational Needs of Population of the Upper-Silesian Industrial Region); Silesian Technical University Architectural Designing Institute; and the Greens Management Department of the Academy of Agriculture of Warsaw (research on the Overall Design of the Dolina Trzech Stawów Recreational Area in Katowice. The Katowice Municipal Park: a Conceptual Study); and the Central Mining Institute in Katowice (research on Hydrogeological Investigation for the Dolina Trzech Stawów Recreational Area)

The cooperation with research institutions in designing the USIR Forest Shelterbelt recreational areas ensures the designed areas an optimum character — that is, a functional system with the most reasonable use for recreational purposes of such an important natural factor as is the forest.

The overall concept of the Shelterbelt development provides for the completion by 1980 of a total of 150 recreational areas over a total area of 195 thousand hectares. The advance of the preliminary work and the work completed to date indicates over an area of 39 thousand hectares of the forests designed for the Forest Shelterbelt Development that a total of 83 recreational areas are to be ultimately developed, of which 46 areas are under construction. In the immediate future a further 18 areas will go under development, whereas the remaining 19 areas will be organized following necessary land adaptation projects, such as numerous land improvement and reclamation operations. Thus of the 150 planned recreational areas 82 are under development or at an advanced stage of the preparatory work preceding the development stage.

Organization of the development of the USIR Forest Shelterbelt has been founded on 14 Local Public Forest Shelterbelt Recreational Area Development Committees subordinated to the Voivodship Forest Shelterbelt Recreational Area Development Committee. The Local Committees in a fully incorporated capacity are composed of representatives of enterprises and civic organizations. The Committees' tasks are to ensure adequate funds for preparation of the specifications, for aquisition of materials, and to organize executive bodies which are specialist construction enterprises and voluntary actions. The number of tasks taken on along the lines of development of the recreational areas by the Local Committees ranges from one area (Chorzów, Świętochłowice, Bytom, Mysłowice, and Zawiercie) to five (Katowice, Gliwice, Zabrze), and six (Tychy), depending upon the existing local topographic conditions and the size of a particular recreational area concerned.

A considerable momentum of the development operations, which begin from their preceding designing and specifications work often performed on a gratuitous basis as voluntary actions, is evidence of a substantial understanding of the idea of the Forest Shelterbelt among the general public of that region.

An incentive for increased activity along these lines are continual proposals advanced for recreational development of the forest complexes situated near large towns which would, thereby, incorporate these areas into the sphere of their functional use in conformity with the city development plans. An example of such a proposal may be the concept of the development of the Municipal Park for the city of Katowice based on incompletely developed peripheral forest where the Dolina Trzech Stawów Water Sports Recreational Area is localized and is currently under expansion. The Area, situated southeast of the city, was developed on the basis of the low birch and pine forest stands extending along the Leśny Potok valley. The Leśny Potok creek, which heads at the Murckowskie Woods at a distance of 2 km, forms in its lower run a few overflow arms in the form of ponds. Two of these ponds are storage reservoirs for the Katowice colliery, and one — upon previous development — has been changed to a natural swimming pool with a flow-through stream current.

The total area of the recreational area as developed to date equals about 150 ha and is subdivided into the following functional zones: developed forest area — for strolling, children's playground with a wading pool, sports grounds for hand ball, volleyball, swimming pond with adjacent sandy and lawn beaches, a pond for aquatic sports, and an autocamp ground. Convenient connections to the city by mass transportation and individual transportation result in that the area is frequented not exclusively by inhabitants of the nearby settlements but also by inhabitants of the Downtown Katowice, or even by those of other towns of the USIR who are not infrequent visitors there. The location of the Dolina Trzech Stawów Recreational Area had made the party and administrative authorities to assign that area for recreational purposes with the designation of its function as Municipal Park. Conceptual phase of the development project performed in Academy of Agriculture of Warsaw, Parks and Greens Institute under the leadership of Professor Niemirski made it possible to prepare the primary balance of the recreational capacity of the area (Table 2), with a glance to the fundamental functional zones and to the proposed staging of the Park development project. What strikes in that concept is primarily the enormity of the undertaking. The ultimate area of the Municipal Park will be euqual to 1760 ha, while the area of the first stage of the development will be 374 ha. The ultimate area of the Park indicates that this will be the largest development of that kind in this

Table 2

Balance of the Recreational Capacity of the Katowice Municipal Park Area

Land kind	Development stage I			Development stage II		
	total area ha	useful area ha	recreational capacity persons	total area ha	useful area ha	recreational capacity persons
Unforested land, water bodies, meadows, pastures	41	50	2050	32	50	1600
Forest areas, stands aged over 40 years	183	20	3660	1077	20	21,540
Land excluded from recreational use	131	—	—	324	—	—
Farmland	19	2	38	12	2	24
Total natural recreational capacity	374	—	5748	1445	—	23,164

country which is fully justified by its functionality and the dimension of the public demand. The expected maximum capacity of the area will amount to 80,000 people. In the Park designed the following facilities are to be provided:

— 9 childrens' playgrounds over an area of 18.70 ha,
— 8 sports ground complexes of an area of 12.0 ha,
— 2 recreationally adapted natural water bodies of an area of 4.8 ha,
— entertainment places such as a movie theater, a reading room with library, newspaper reading room, entertainment club, mass boarding buildings, buildings for accommodations, a pioneer's center, and a camping ground, squares for rest, finally such facilities as rain shelters, sports outfit rentals, administration Park buildings (along with premises for materials and equipment storage of the Board of Greens Management), alleys and paths for walking and hiking, highways, and parking lots (Table 3).

Table 3

Planned Facilities of the Katowice Municipal Park

Facilities	Number of facilities	Area, ha	Number of users
Childrens' playgrounds	9	18.30	3562
Sports facilities	8	31.00	3100
Swimming areas	2	48.00	24,000
Kayak landing stage	1	0.45	75
Angling club	1	1.00	200
Entertainment facilities	5	1.25	2990
Mass boarding facilities	31	5.04	4130
Year-round accommodations	10	23.00	1880
Seasonal accommodations	5	20.00	2500
Passive recreation	—	166.38	19,000
Transportation facilities, highways, parking lots	10	20.00	—
Other facilities:			
— toilets	14	0.70	—
— rain shelters	12	0.90	—
— sports outfit rentals	5	0.02	—
— sports facilities	1	14.44	—
Total	116	446.73	62,387

The scope of the development design of the Municipal Park in Katowice should be rated as preliminary and subject to discussion in both the social workers' circles and among the authorities, as well as a subject to a vast criticism from the general public which evidently is going to be the main executor of this enormous undertaking.

It is unquestionable that the expansion of the Dolina Trzech Stawów Recreational Area, as one of the USIR Shelterbelts Recreational Areas, to the size of the largest municipal parks on a European scale is evidence of the seriousness of the problem of the environment protection in that region and calls for further actions, on the part of the authorities, to solve this problem.

The development operations related to the USIR Forest Shelterbelt proceed at a high pace, which is an incentive in putting forward new proposals which, in the case of the design to expand the Dolina Trzech Stawów Recreational Area to the Municipal Park, result in that the problems of the Forest Shelterbelt areas become part of the body of problems related to city planning.

It will be noted that the concept of the USIR Forest Shelterbelt may meet with a still better understanding with the representatives of industry on the ground of the coupling of the problems, related to the development of shelterbelts for annoying industrial plants, into a large project of reconstruction of the forest stands on the areas adjacent to these plants. Such a cooperative approach could hopefully contribute a great many new proposals as to the scope and nature of the newly designed recreational areas. This would undoubtedly have some bearing on the procurement of additional funds and material resources available from industry for joint development projects.

Prepared by W. Zajer

AIR POLLUTION CONTROL IN THE PROVINCE OF SASKATCHEWAN, CANADA

The Air Pollution Control Act in the Canadian Province of Saskatchewan was passed in 1965 According to this act responsibility for control of the air pollution sources was divided between the administration of the Province and the municipalities. The latter are responsible for the abatement of pollutants from such sources as motor vehicles, garbage incinerators, home furances, whereas the administration authorities of the Province supervise industrial plants.

The admissible emission level for the pollutants released by particular emission sources and their threshold limit values in the atmosphere over specified areas have been enacted on the basis of the Act. The above standards will, however, be updated from time to time with improvement in

the air pollution measuring methods, increased density of industrial plant and the progress in research on the effect of emissions on the natural environment. The Act provides also the regulations relative to the ways of controlling the motor vehicle emissions.

The responsibility for the air pollution control was entrusted to the Ministry of Public Health. In view of the complexity of the problem, however, and the need to deliver expert's awards and reports, the Act admits the Air Pollution Control Advisory Committee to be appointed. Members of that Committee should have an engineering background or professional experience needed in passing opinions related to the air pollution control problems.

The municipalities will be able to pass their own regulations, especially those concerned with garbage incineration and to the home furnace emissions, or else they can follow the rules enacted by the administration of the Province. However, all the rules and regulations are subject to approval by the Minister of Public Health to ensure uniformity of the legislature.

The regulations in force also provide the period of time to enable the proprietors and/or users to conform to the recommendations given by the authorities relative to the reduction of emission released from the sources operated by the aforesaid proprietors and/or users. The deadline in question is 60 days for industrial plants and 30 days for municipal sources.

In case the recommendations of the authorities are not conformed to, penalties are provided. Specifically, for repeated violations of the admissible daily emission standards a penalty inflicted on private persons and on the companies are Can. $ 25 and 500, respectively. There is a right of appeal from the decisions of the authorities of the Province to the Queen's Court Judge whose judgment is final.

The air pollution control project in Saskatchewan, where the atmospheric pollution is still a minor problem, differs from the analogous projects launched in other heavily industrialized Provinces. This is why in Saskatchewan a strong emphasis is placed on the preservation of the present quality of the atmospheric air and on the countermeasures against a rise in pollution level since the earliest stages of the industrial and urban development.

In the capital of the Province, Regina, as well as in the other major city of Saskatoon, the concentration of fumes is generally low. In winter — that is, in the "dirtiest" season of the year, an estimated 12 percent alone of the measurements of pollution level carried out in downtown Saskatoon were regarded as exceeding the admissible standards, whereas in Regina the corresponding value was 3 percent. The low air pollution level in

those cities is due to the use of heating oil both in industry and in residential buildings.

In some areas, however, an increased air pollution is observed which largely results from operations of oil refineries, the oil storage and loading stations, and to a lesser extent from the individual formers' tanks. However, the major nuisance the population complains about are odors. In Regina, for instance, the effect of darkening of finishes of the outside house walls was noticed. The darkening observed was a result of the hydrogen sulfide emission whose concentration at that time averaged 0.045 ppm over a 2-hr period. Today the episodes of air pollution with hydrogen sulfide or with other odors from oil tanks and refinery are infrequent.

A serious problem that is rather hard to control are dust storms. They are caused by high, frequently stormy, dry westerly winds whose mean speed ranges 10 to 20 m/sec. The winds blow away the particles of dried surface soil, followed by their transport and accumulation. The vertical range of these dust storms is 2 to 2.5 km and their extension is 2 to 3 or occasionally even 5 thousand km.

The occurrence of dust storms in Saskatchewan may partly be blamed on intense farming. The prairie having been brought under cultivation, the grass and shrub vegetation characteristic of that climatic zone was destroyed which deprived the soil of an efficient protection against eolian erosion.

Another source of atmospheric pollution are herbicide manufactures. Even though the manufactures of 2,4-D (2,4-dichlorophenoxyacetic acid) herbicide are localized away from urban settlements, the escaping dust caused injuries to the garden plants.

The purity of air in Saskatchewan is also threatened by the developing manufacture of potassium salts based on the local resources. In the neighborhood of manufactures of that kind damage to natural vegetation is observed which is essentially due to increased salt content in the soil. Expectedly, the destruction of the green cover will be parallelled by the planned development of that industry.

Of other industrial plants situated away from the urbanized areas mention should be made of cement plants, power plants, and fertilizer plants.

In the Province of Saskatchewan on the other hand there is no pollution from motor vehicle exhausts. This is due to a high grade fuel used, good technical condition of the cars, and a small number of Diesel-engine cars.

It is feared, however, that parallel with industrial expansion into Saskatchewan the potential pollution sources may increase. For that reason the Air Pollution Control Act is a significant accomplishment of the Prov-

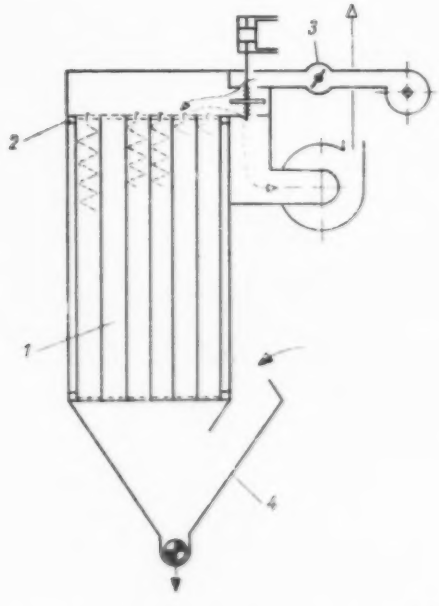
ince. This reflects itself in the ready acceptance, both by municipalities and by the administration of the Province, of the need to take efficient measures to preserve the reservoir of pure air in Saskatchewan (see Fresh Air from Saskatchewan — Air Conservation, No. 2, 1973, p. 73).

Prepared by M. Świeboda

PATENT REVIEW

A Fabric Filter for Dust Collection from the Air and Gaseous Effluents

Inventors: Maria Gębica, Marian Borkowski, Józef Czerkowski, Andrzej Albrecht, Janusz Świtakowski, Kazimierz Hondra, Walerian Domiński, Andrzej Sokołowski
Patent owner: Designing Office of the Cement and Lime Industry Cracow, the "Kowent" Dust Collection and Ventilation Equipment Manufacture, the "Trzusławica" Konin Lime Industry Manufacture at Sitkówka
Filed: December 1, 1972
Published: September 30, 1973
No.: P-159,217
Cl.: 50 e



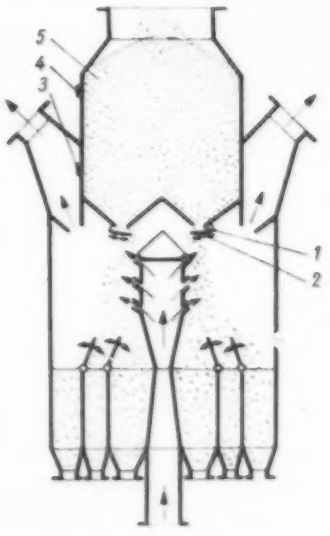
A fabric filter for dust collection from the air and gaseous industrial effluents composed of a box-shaped hausing tapered downward into a dust hopper, and equipped with guides, a collecting chamber unit accommodat-

ed in the housing, and with an exhaust collector and a reversed-air collector, a reversed-air unit incorporating a fan and a pipeline; said filter has a pulsator, and valve chambers, featured by that it has filter fabric *1* sawn in the form of a bag unit, and accommodated in the openings between the support guides *2*, the bag unit being fastened at the four corners of individual chambers with the aid of snap hooks; said filter has a drum butterfly pulsator *3* common for all the chambers, as well as a reversed-air and exhaust distribution system, separate for each chamber, equipped with a single-head damper with double travel adjustment, and with a sealing provided in the filter bottom section in the form of a fully housed fine-thread worm with a thread gap, the said worm extending outside the dust hopper *4*.

P.P.

A Pneumatic Separator

Inventor: Jan Marzec
Patent owner: "Dozamet" Lower-Silesian Metallurgical Plant, Nowa Sól
Filed: December 6, 1972
Published: September 30, 1973
No.: P-159,313
Cl.: 50 e



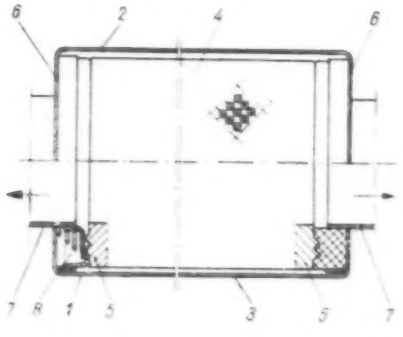
A pneumatic separator designed for sizing materials of different specific gravity — especially for separation of various impurities produced in the shot blasting operation from the shot — incorporates two tanks one of which, constituting the fouled shot tanks, is provided with at least one charging hole, characterized by the feature that on the charge hole *1* a swivel damper *2* is provided, said damper is actuated by pulses formed by preferably two known level sensors *3* and *4* situated at various levels inside the tanks 5.

P.P.

An Air Filter for Engine-Powered Machines and Compressors

Inventor: Edward Szulaczkowski
Patent owner: Stalowa Wola Metallurgical Plant
Filed: September 30, 1971
Published: September 30, 1973
No.: P-150,831
Cl.: 50 e

A cartridge air filter, especially for machines and compressors powered by internal combustion engines, with a collecting pipe accommodated at the center of the filter and coinciding with the longitudinal axis of the fil-



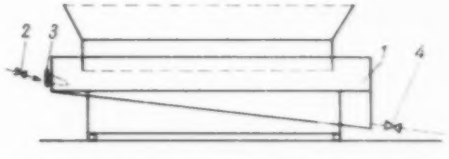
ter; said filter is placed in a housing and is characterized by the feature that the generatrix *1* of housing *2* has an opening *3* of a shape equal to or larger than the length and the diameter of the cartridge *4*, and that on one or both sides of housing *2* directly or indirectly between the cartridge face

5 and the wall 6 of housing 2, and between generatrix 1 of housing 2 and the exhaust pipe 7, there is a lock ring 8 that holds cartridge 4 in place in housing 2.

P.P.

A Device for the Removal of Slag from under the Steam or Water Boiler Furnaces

Inventors: Otmar Kowalski, and Sylwester Kempa
Patent owner: the "Kotłomontaż" Assembly and Overhaul Chemical Industry Plant, Gliwice
Filed: July 21, 1969
No.: W-47,491
Cl.: 42 g



The device consists of a slag pan and is characterized by the feature that the pan itself 1 has a sloped bottom and is equipped with an inlet tube 2 provided with an induction nozzle 3 and with an outlet tube 4.

P.P.

NEWS IN BRIEF

DOCTORAL AND HABILITATION DISSERTATIONS IN 1972

Marian Kwiatkowski: Chemical and Thermal Methods of Removal of Oxides of Nitrogen from Waste Gases in Organic Synthesis Industry (Technical University of Szczecin, Faculty of Chemical Technology; October 13, 1972; Professor Dr. Józef Kępiński).

The study is concerned with the effects of disposal into the atmosphere of the waste gases containing a mixture of oxides of nitrogen, referred to as nitration gases, and the current methods used in the removal of these nitrogen oxides from the waste gases are reviewed. Activity of ten or so catalysts is compared which are employed to promote the carbon monoxide process of nitrogen oxides reduction. Process variables were also examined for a noncatalytic nitrogen oxides reduction with carbon in the form of coke, the process in which the organic vapors accompanying nitrogen oxides are also burned. The usefulness of both methods of nitrogen oxides reduction was estimated and feasibility of coupling of the process design developed to the organic synthesis industry was analyzed.

Tadeusz Bronikowski: Sulfur Dioxide Removal from Dilute Process Gaseous Effluents with the Production of Sulfuric Acid by a Solution Catalysis Process (Institute of Physical Chemistry of the Polish Academy of Sciences, Warsaw; May 4, 1972; Docent Dr. Wiesław Kawecki).

The dissertation deals with kinetics of the process of simultaneous absorption of SO_2 and O_2 in solution which involves oxidation of SO_2 in the presence of a catalyst to form H_2SO_4. The absorption process was run in a single-stage foam scrubber. The experiments made on a smaller scale of 500 m^3 (S.T.P.)/hr resulted in a semiempirical formula which accounts for the effect of the process temperature, the substrate and product concentration on the rate of the oxidation reaction. Gaseous mixtures and solutions used in the investigations corresponded to the actual process feedstock. Soluble iron salts were used as the catalyst. Results of the small-scale experiments were subsequently checked in a tenfold larger scale of 5000 m^3 (S.T.P.)/hr which is equivalent to a pilot-plant scale.

Bogumiła Cwynar-Sokołowska: Influence of the Industrial Atmosphere on the Metal Corrosion Processes on the Example of the Legnica Copper Metallurgical Plant (Technical University of Wrocław, Institute of Chemical Engineering and Heating Equipment; June 26, 1972; Professor Dr. Bohdan Głowiak).

In the part devoted to literature review discussion is given of such problems as industrial corrosive environments, physicochemical processes on metal surfaces, and electrochemical corrosion cells. In the experimental part the procedures used and the results obtained are treated. The research program included: (1) determination of the average and maximum concentrations of the agressive agents in the atmosphere, (2) investigation of the spatial distribution of air pollutants over the area concerned, (3) collection of data as to the character of the corrosion damage and chemical composition of the corrosion products formed, (4) evaluation of the corrosion rate for engineering metals exposed to a variety of corrosive media, (5) measurements of electric quantities characteristic of the performance of the corrosive microcells. On the basis of the results obtained conclusions were made with reference to the environment examined and to the mechanism of atmospheric corrosion of construction metals.

Zdzisław Matyniak: Catalytic Oxidation of the Evaporation and Decomposition Products of Some Enamel Brands (Technical University of Wrocław, Institute of Chemical Engineering and Heating Equipment; February 22, 1972; Professor Dr. Bohdan Głowiak).

The aim of the work was a comparative study of the process of catalytic oxidation of waste gases from paint-baking ovens, conducted with certain domestic catalysts and a foreign KAVAG catalyst. Results of the investigations proved that for the domestic catalysts a gas treatment efficiency achieved is higher than, or at least equal to the efficiency obtained for the foreign catalyst. Based on the economic grounds and on feasibility of manufacture of the catalysts investigated, several process catalyst units were prepared using MCA-1 catalyst. This catalyst was not inferior to the foreign-made catalyst in the laboratory studies and, as opposed to other catalysts, is inexpensive and available on an industrial scale. The tests made on the efficiency of catalytic oxidation of the paint-baking oven waste gases under process conditions showed a satisfactory activity of this catalyst which matches that of the foreign-manufacture catalyst.

Mieczysława Tarajkowska: Influence of Urban and Industrial Areas on the Local Climate on the Example of Częstochowa (University of Łódź, Faculty of Biological and Earth Sciences; June 13, 1972; Professor Dr. Stanisław Zych).

The dissertation is concerned with the influence of local factors on meteorological elements. The spatial range of these influences was quantitatively estimated. The problem of differentiation of the pollutant distribution in the city is treated. The study was based on the measurement data from the Częstochowa State Hydrometeorological Institute Station for a period of 1924–1965 for Częstochowa, and for a period of 1955–1959 for Wieluń, Przedbórz, Sternalice, Kochcice, and Olesno, as well as on own measurement data collected from continuous or periodic measurements made in Częstochowa over a period of two years. Emphasis was placed in the study on the climate elements which are substantially affected by the local factors.

Henryk Ginel: Changes in the Agricultural and Natural Environment Caused by Operation of the Konin Brown-Coal Mine (College of Agriculture in Poznań, Faculty of Agriculture; June, 16, 1972; Docent Dr. Eugeniusz Matusiewicz).

Over the area of the Konin District power industry plants and an aluminum metallurgical plant are localized which operate there on the basis of brown coal natural resources. These developments affected the agricultural and natural environment. The analysis of that environment carried out by the author demonstrated that some adverse effects of industrialization are observed in that area. Intense development of industry in Konin District had no major effect on agricultural production until 1970; the production merely dropped in intensity. The author makes a suggestion that by means of recultivation possibly the most land should be turned back to farming, whereas too high dumping grounds and thus unsuitable for farming purposes should be brought under forestry management projects. State farms should be the prospective users of that land. Designation of that land for fruit and vegetable production will improve supply for the Konin Industrial Region.

Henryk Kordus: Organization of the Environment Protection Education against the Background of Today's Problems (Academy of Agriculture of Warsaw, Faculty of Horticulture; July 12, 1972; Professor Dr. Alfons Zielonko).

The subject of the work in brief is the biological and cultural environment crisis, its effects, symptoms, the reasons for it and the measures to prevent this crisis by means of educating and instructing the general public on a large scale.

Jan Tadeusz Bartkowicz: The Regional Planning Problems of Expanding Cities and Settlements under Conditions of Continuous Atmos-

pheric Pollution (Cracow Technical University, Faculty of Architecture; June 30, 1972; Professor Zbigniew Wzorek).

The study is concerned with planning and development of settlement complexes expanding over the areas featured by a high level of atmospheric pollution. In broadest terms the study attempts to throw more light on the relationships and interconnections between the planning and development of an urban area on one hand, and air pollution on the other. It also attempts to determine the necessary changes to be made in the urban environment organization as to its spatial layout which is a condition for a minimized health and life hazard of the population inhabiting the areas exposed to an incessant and prolonged emissions fallout.

Bolesław Raczyński: The Effect of the Filter Bed Shape on Filtration Efficiency (Polish Academy of Sciences Industrial Region Environment Protection Department; October 27, 1971; Professor Dr. Roman Andrzejewski).

The investigations were carried out with low-dispersion aerosols of cement, graphite, and iron oxide on loose-packing filter beds such as steel balls, cylinders, or cubes, and also cement clinker, metallurgical sinter, and blast-furnace coke. Analysis of the results of the experiments in terms of relevant theoretical considerations demonstrates that among the controlling factors for the filtration efficiency are impingement mechanism, bed particle adhesion coefficient, and the bed particle size factor. A formula was derived which relates all these quantities. Results of the experimental studies and the theoretically derived formula for filtration efficiency of the bed filter permitted the filtration coefficient values to be found. The formula is of assistance for improvement in design of the loosely packed bed filters in use.

Irena Szalonek: Some Aspects of the Effect of Industrial Atmospheric Pollutants on Vegetation with Particular Attention to Fluorine Compounds (College of Agriculture in Cracow, Faculty of Agriculture: December 18, 1971; Professor Dr. Jan Paluch).

The range of the toxic effect of fluorine and other air pollutants on plants was determined in the study. Accumulation of fluorine and sulfates in plants was examined. Sensitivity of particular plant species to fluorine was determined, as well the harmful effect of the fluorine present in the soil in the emission areas on plants and accumulation of fluorine in plants. As a result of the study of the fluorine accumulation in plants the range and the degree of hazard for animals and humans were determined —

the life hazard that arises from the fact that animals and humans feed on the fluorine-contaminated plants.

Piotr Andrzej Grzywacz: The Influence of the Industrial Atmospheric Pollutants on Certain Pathogenic Fungi of Forest Trees (Academy of Agriculture of Warsaw, Faculty of Forestry; July 10, 1972; Professor Dr. Jerzy Ważny).

On the grounds of statistical data the occurrence of certain pathogenic fungi of interest for forest management was investigated in forests of industrial areas and in two selected forest district administrations. It was found that the atmospheric pollutants bring about substantial changes in the species content and in the number of fungi. Some fungi species are promoted, some others are decreased in number, whereas other sensitive species vanish. A number of the fungi species of minor importance exhibit appreciable activity. This may become a new problem for biological control of forests. The second part of the study is devoted to investigation of the effect of SO_2 on the growth of test fungi species under laboratory conditions. It was explained what relationships occur between the physiological activity of the fungi and their sensitivity to SO_2. As a measure of this activity were assumed: respiration rate, the content of seventeen aminoacids, and the total nitrogen in the dry weight of the spawn. The effect of fumigation on the acidity of the nutrient medium and a changed natural immunity to the fungi-induced decomposition of pine timber, which originates from the stands damaged to a various extent by atmospheric pollutants were investigated.

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MISCELLANEOUS

The Silesian Medical Academy to Support the Environment Protection Cause

Of a substantial and many years' accomplishments in the fight for the preservation of the natural environment of man can boast the Silesian Medical Academy. This Institution is largely focused on the protection of health of the population. Results of the experiments and the experience gained in this field are for the first and immediate practical use by the crew and personnel of the plants in the voivodships: Opale, Wrocław, Cracow, Gdańsk, Warsaw, and in the mother region of Silesia and Zagłębie.

Cooperation of the Academy with industry is primarily concerned with these industries whose operation exerts the most adverse influence on the nature and which are the source of most nuisances as noise, vibrations and pollution of air with dusts and chemical compounds in the immediate surroundings of the worker. The cooperation, therefore, includes such industries as mining, and metallurgy; chemical, machine building, pharmaceutical, electronic, and farm produce and food processing industries.

In recent years much attention is being paid to the prophylactics. For that purpose cooperation was initiated also with technical educational institutions, as Silesian Technical University, the Cracow Academy of Mining and Metallurgy, and with the Polish Academy of Sciences.

A number of research projects is currently at an advanced stage of progress to be used by the domestic industrial plants and enterprises, such as the effect of temperature, air moisture content, dust concentration, and chemical contamination of the air with oxides of sulfur and nitrogen, with carcinogens and oxidants. The investigations are conducted in the „Baildon" Ironworks, the "Energopomiar" Research and Measurement Plant of Power Industry in Gliwice, the Paweł Finder Nitrogen Plant in Chorzów, Czechowice Oil Refinery, the Katowice Petroleum Products State Company (CPN), and in the Domestic Glassware Works at Zawiercie.

Prepared by J. L. after PAP sources

The Youth of Łódź for the Protection of the Environment

The environment protection problem has a peculiar significance in the Łódź region. This area has exceptionally adverse natural conditions for man and the entire biosphere.

Early development of industry there and irrational timber exploitation resulted in that the forest area of the Łódź Voivodship is below the national average. Moreover, some of its regions are less insolated than the neighbor areas which is due to increased particulate matter and gaseous emissions in the region. The city of Łódź itself ranks among the most polluted by industry with dust and toxic compounds cities of Poland. For illustration, the measurement of dust concentration in years 1966/1967 showed that over 40 percent of the area of that city the dust concentration exceeds the admissible standards for dust fallout — that is, the value of 250 tons/km² during a year.

These problems have attracted attention of the youth of Łódź, and especially of the engineers, technicians and economists directly employed in industry or in research and development institutes. They have adopted a motto that the environment protection will be their primary objective in their professional activity. Youth organizations and, particularly, the Socialist Youth Union, promote novel technical improvement ideas in the field of the environmental protection and urges their underlayed implementation.

Prepared by J. L. after PAP sources

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